GEOLOGY OF MULDOON AREA

FAYETTE COUNTY, TEXAS

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GEOLOGY OF MULDOON AREA
FAYETTE COUNTY, TEXAS

THESIS

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Frontispiece

Aerial view of fault line trace trending N. 65° E., west of Muldoon-West Point county road, 1.8 miles northeast of Muldoon, Fayette County, Texas.

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ABSTRACT

This paper presents a detailed geologic map of the Muldoon area, southwestern Fayette County, Texas. Strata outcropping in the area are the upper Yegua formation of the upper Claiborne group, the Caddell, Wellborn, Manning, and Whitsett formations of the Jackson group of the Eocene, and the Catahoula and lower Oakville formations of the Oligocene and Miocene.

The stratigraphic section consists of approximately 900 feet of sediments and is a compilation of 27 individual surface exposures tied in stratigraphically.

The regional dip in the area is to the southeast, varying from 68 feet per mile for the lower Oakville formation to 129 feet per mile for the Wellborn formation.

Faulting in the area is restricted to minor normal faults with displacements up to 10 feet cutting the Carlos sandstone outcrop.

The basal Caddell sands were analyzed in the laboratory to determine the size frequencies, heavy minerals, and glauconite content.

A list of plants growing in the area is included. Both presence and importance of the species found on each formation is indicated by field-assigned numbers.

INTRODUCTION

Purpose and Scope

The purpose of this work was to study in detail the stratigraphy of the Jackson group, the Catahoula, and the lower Oakville formations in the Muldoon area, southwestern Fayette County, Texas. For this purpose the lithology and thickness of exposed sections were described and measured. These separate sections were correlated and tied in with each other by lithology or by elevations and combined in form of a composite section (Plate II). In order to obtain a more precise lithologic description of the basal Caddell sand, sieve analyses and determinations of the heavy-mineral content and per cent of each mineral species present were made. For the same purpose the nature and distribution of the glauconite in the basal Caddell sand in relation to the underlying disconformity were investigated.

A botanical survey was made to obtain a general idea of the vegetation present in the area. Results of this survey are summarized in a list showing the presence and importance of the species found growing on each formation. (Table 12.)

Location

The area mapped is an irregular rectangle, 7 miles long

and 7 to 8 miles wide, in the vicinity of Muldoon, southwestern Fayette County, Texas. The measured and described sections are along creeks and gullies within a 5.5 mile radius of Muldoon, Texas. Muldoon is located 10 miles northeast of Flatonia on Farm road No. 154 and approximately 65 miles southeast of Austin, Texas.

Field Methods

Formation contact points were established by foot traverse and plotted on aerial photographs. Unexposed contacts were estimated with the aid of a stereoscope. A base map was assembled to a scale of 1 inch to 1056 feet from the aerial photographs. Geologic features, survey lines, and all prominent land marks such as roads, houses, streams, pits, and quarries were plotted directly from the photographs. Locations of the survey lines were obtained from a land ownership map, which the writer borrowed from the Fayette County tax collector and assessor. The survey lines were transferred onto the aerial photographs and used as control points in the assembling of the base map. Altitudes were obtained from permanent United States Coast and Geodetic Survey bench marks or from supplementary elevation points established by barometer. Most of these supplementary altitudes were established on contacts of geologic formations and plotted on the geologic map. Dip

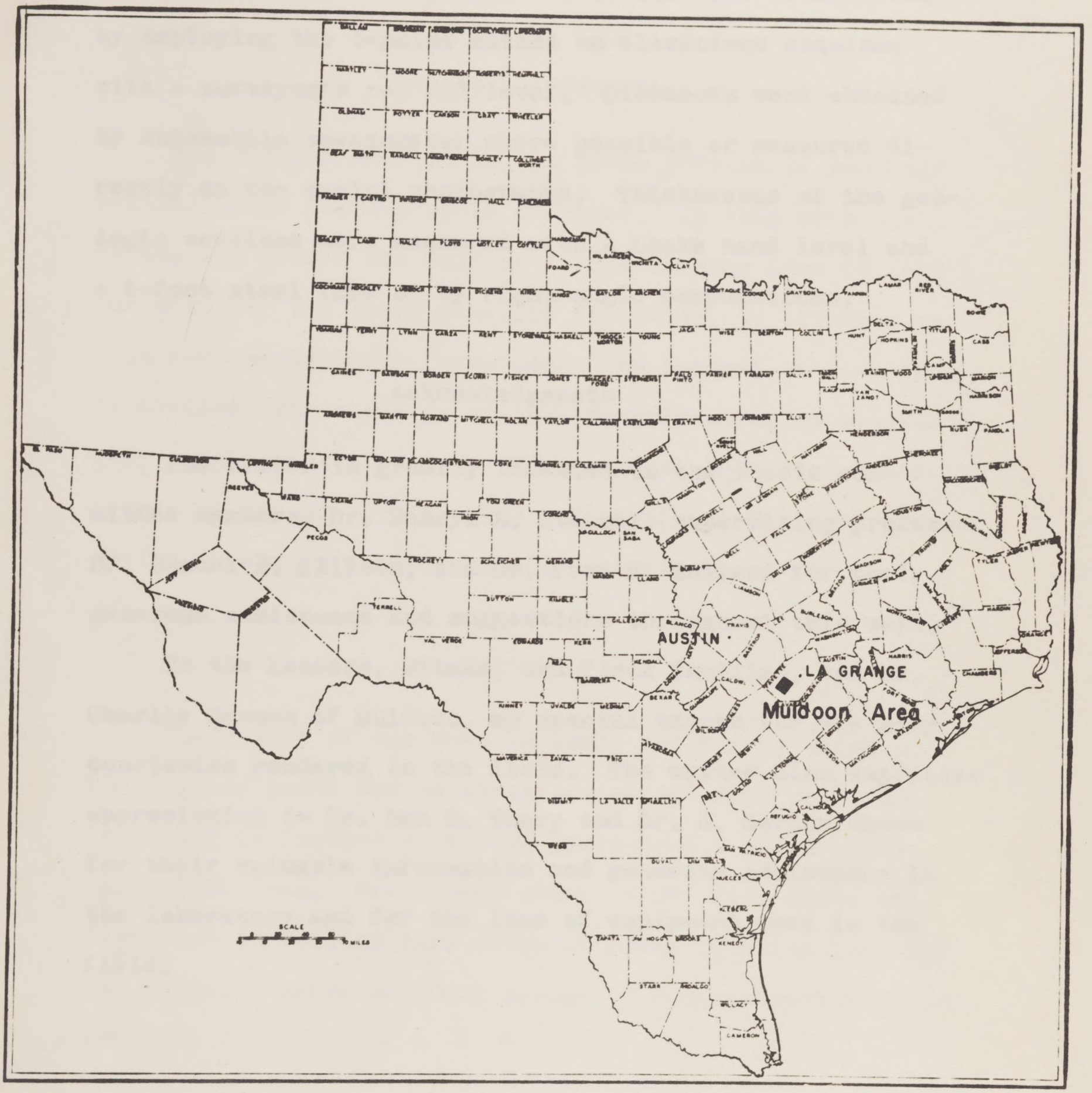

Figure 1. Index map of Texas showing location of Muldoon Area

and strike of limited persistent strata were established by employing the 3-point method on elevations obtained with a surveyor's rod and level. Distances were obtained by automobile speedometer where possible or measured directly on the aerial photographs. Thicknesses of the geologic sections were measured with a Locke hand level and a 6-foot steel tape or by right angle computations.

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PHYSIOGRAPHY

General Statement

The Muldoon area is in the Texas portion of the Gulf Coastal Plain physiographic province. In this area the strata dip toward the Gulf at a rate ranging from 68 feet per mile for the lower Oakville formation, to 129 feet per mile for the Wellborn formation. The present land surface is divided into a series of low, roughly parallel cuestas with gentle back slopes to the southeast and steeper inface slopes at the northwest. The inface of the Wellborn formation cuesta is a pronounced erosional scarp.

Relief

The relief of the area is small and fairly uniform. The highest point has an elevation of 463 feet above sea level and is located at a road junction 6.5 miles southeast of Muldoon. The lowest point is 296 feet above sea level and is located just south of Rocky Crossing Lake and the Buckners Creek Railroad Bridge, 2.5 miles northeast of Muldoon.

Drainage

The area is drained by a dendritic system of inter-

mittent streams having a low gradient. The principal streams are the subsequent, northeast-flowing Live Oak and Pin Oak creeks, which drain into the Buckners Creek.

STRATIGRAPHY

General Statement

The formations exposed at the surface in the Muldoon area are of Middle and Upper Eocene, Oligocene, and Middle Miocene age. The Yegua formation is the oldest and outcrops in the northwest part of the area; the Oakville is the youngest and outcrops in the southeast part of the area. Much of the surface in the area is irregularly mantled by thin deposits of recent soil.

EOCENE

CLAIBORNE GROUP

Yegua formation

Outcrop.- The Yegua formation outcrops along the northwest edge of the Muldoon area. A strip of the upper Yegua up to 1 mile wide is included on the map (Plate I).

Topography.- The topography of the upper Yegua formation is level to gently rolling.

Lithology.- The upper Yegua strata consist of light gray, cross-bedded sands and chocolate-brown to gray, massive to poorly bedded, silty, bentonitic clays with abundant lignitized plant matter.

Stratigraphic relations.- The Yegua formation, proposed

System	Series	Group	Formation	Member
Quaternary	Holocene		Alluvium	
Tertiary	Middle Miocene		Oakville formation	Lower Oakville clay
	Upper Oligocene		Catahoula formation	
	Eocene	Jackson group	Whitsett sand	
			Manning formation	
			Wellborn formation	Carlos sandstone Member Middle Wellborn
			Caddell formation	
		Claiborne group	Yegua formation	

Figure 2. Table of formations

by Dumble (1892, pp. 148-153), is overlain disconformably by the Caddell formation. The upper surface of the Yegua clays is uneven and clearly erosional. The overlying Caddell consists of cross-bedded, slightly glauconitic, silty sand and glauconitic, calcareous sandstone enclosing aragonite concretions. Locally there are fossil animal burrows extending from the Caddell into the Yegua for several inches. These burrows are irregular in shape and filled with the overlying glauconitic sands of the Caddell.

Soils and vegetation.- The soils consist of a dark-brown sandy loam, on which grow post oak, black jack oak, cedar, and grasses. In the vicinity of the creeks, hickory and elm are present. In general, the improved parts of the land are used for grazing.

Environment of deposition.- The lithology of the upper Yegua strata indicates that the deposition occurred in a terrestrial environment bordering the coast. Streams flowing across the area deposited the cross-bedded sands, silts, and clays. Sediments containing lignitized plant material, which coalesce with the fluviatile deposits, were deposited in coastal marshes. The bentonitic material present in the clays was probably derived from volcanic ash falls which prevailed toward the close of Yegua time.

JACKSON GROUP

Caddell formation

Outcrop.- The Caddell formation outcrops at the surface in a belt 1 to 2 miles wide and extends in a general northeast to southwest direction across the area.

Topography.- The topography of the Caddell is very gently rolling.

Lithology.- The Caddell formation consists mostly of gray and tan, lenticular to cross-bedded sands and gray to chocolate-colored clays. Interbedded with these are sandy clays, tuffaceous sands, bentonitic clays, and carbonaceous shales. Many of the sands and clays contain lignitic material and minor amounts of silicified wood. Slightly glauconitic sands and bentonitic clays interbedded with lenses of calcareous sandstone enclosing aragonite concretions and a few invertebrate fossil casts occur in the basal part of the formation.

Stratigraphic relations.- The Caddell formation, first described by Dumble (1918, pp. 177-178) as the basal Jackson beds, rests disconformably on the Yegua formation. In the southwest part of the Muldoon area, the basal Caddell contains lenses of calcareous sandstone enclosing aragonite concretions interbedded with slightly glauconitic sands and bentonitic clays. The first calcareous sandstone in the basal Caddell occurs in the east road ditch, 1.35 miles south

from Parkerville along the county road. Upon weathering, the sandstone leaves numerous aragonite crystals. Occasionally a few invertebrate fossil casts occur in this sandstone. To the northeast, the basal Caddell consists of slightly glauconitic sands interbedded with bentonitic clays, and the calcareous sandstone is absent. In a contact exposure in the east bank of a county road cut near the northwest corner of the E. Cherry 182-acre tract, 1.78 miles northwest of Muldoon, the Caddell glauconitic sands and clays rest on a wavy, erosional surface of the Yegua carbonaceous clays. Fossil animal burrows extending from the Caddell into the Yegua for several inches are filled with Caddell material. The glauconitic sand in the basal Caddell formation is similar in stratigraphic position to the Moody's Branch marl at Jackson, Mississippi, and can be traced into it; hence it is the lateral equivalent of the Moody's Branch glauconitic marl.

Soils and vegetation.- The Caddell formation weathers to a red-brown to grayish-tan clayey sand and sandy loam. Vegetation consists of a sparse to thick growth of post oak, black jack oak, and cedar. Some hickory and elm grow in the vicinity of creeks. Most of the improved land supports a cover of grasses and is used for grazing.

Environment of deposition.- The basal Caddell sediments in this area were deposited at or very near the strand

line of the Caddell sea which encroached upon the continental Yegua strata. The basal glauconitic Caddell sand and calcareous sandstone represent the initial sediments of the shallow sea. Later, the sea gradually retreated, and the remainder of the Caddell sediments possibly accumulated under fluviatile and brackish conditions on a relatively low, flat coast.

Wellborn formation

The Wellborn formation, described by Kennedy (1893, p. 45), is composed of two portions in the Muldoon area. The lower portion, equivalent to the middle part of the Wellborn formation of Brazos County to the east, is the Middle Wellborn sands. The upper portion is the Carlos sandstone, which was introduced by Renick (1936, p. 31) for the sandstone member at the top of the Wellborn formation. The Bedias sandstone, the basal bed of the Wellborn formation of Brazos County, is absent in the Muldoon area.

Middle Wellborn

Outcrop.- Northeast of Muldoon, the Middle Wellborn outcrops on the steep inface of the northwest-facing Wellborn cuesta as a narrow belt approximately 225 feet wide.

A. Carlos-Middle Wellborn contact. South bank of Buckners Creek on north edge of abandoned sandstone quarry, 50 yards southeast of Buckners Creek Railroad Bridge, M. Muldoon survey.

B. Caddell-Middle Wellborn contact showing two silicified logs at base of Middle Wellborn sands. Old road cut, alongside and on west side of Muldoon-West Point county road, 2.4 miles northeast of Muldoon, Texas.

To the southwest, the inface is gradually reduced to a gentler slope and the width of the Middle Wellborn outcrop increases to about 675 feet.

Topography.- The Middle Wellborn forms the upper part of the steep inface of the cuesta. Were the cuesta is gentler, the Middle Wellborn topography becomes low rolling.

Lithology.- The Middle Wellborn consists of brownish-gray, lenticularly and thinly bedded, slightly carbonaceous, argillaceous, fine-grained sands with thin sandy lignite partings. The sand is partly hardened in small lenses. (See Pl. III, A.) In an old road cut alongside and on the west side of the Muldoon-West Point county road, 2.4 miles northeast of Muldoon, short lenses of hard, grayish chocolate-brown, poorly to thinly bedded, carbonaceous clay containing silicified logs occur at the base of the Middle Wellborn. (See Pl. III, B.)

Stratigraphic relations.- The Middle Wellborn sands rest conformably on carbonaceous silt and shale beds of the Caddell formation.

Soils and vegetation.- The tan to grayish-brown sandy soils of the Middle Wellborn support a sparse cover of post oak, black jack oak, cedar, low shrubbery, and grasses. Locally on the steep slope, the vegetation is very dense.

Environment of deposition.- The lenticular and thinly bedded character of the carbonaceous Middle Wellborn sands

indicates that these beds were deposited for the most part in an environment bordering a shallow sea. The presence of a silicified log riddled with shipworm boreholes in a short carbonaceous clay lens at the base of the Middle Wellborn proves that the deposition took place in a brackish environment, probably in a lagoon.

Carlos sandstone

Outcrop.- The Carlos sandstone outcrops throughout the area in a narrow belt up to 0.5 mile in width. Northeast of Muldoon the resistant sandstone forms a prominent escarpment. Only remnants of the member are present in the southwest part of the area.

Topography.- Northeast of Muldoon the Carlos sandstone makes a prominent escarpment and forms an extensive dip slope. To the southeast, the escarpment is reduced to a low cuesta resulting in a rolling topography.

Lithology.- The Carlos sandstone consists of hard, whitish-gray, medium to massive-bedded, long-lenticular, argillaceous, slightly glauconitic sandstone having a tendency to conchoidal fracture, particularly on the flat top surfaces of the ledges, well developed parallel tectonic joints, and black outside surfaces. Locally the weathered sandstone contains stem or reed impressions, fragments of grayish-white silicified wood, and mollusk casts.

Stratigraphic relations and dip.- The Carlos sandstone conformably overlies the Middle Wellborn sands. (See Pl. III, A.)

The Carlos sandstone strikes N. 12° E. and dips 1° 24' to the S. 78° E. or 129 feet per mile in the Muldoon area.

Soils and vegetation.- The Carlos sandstone weathers into a light gray to tan, sandy soil, which is very thin to locally wanting on the dip slope. The vegetation consists of a sparse cover of post oak, black jack oak, and cedar. Grasses dominate the open areas.

Environment of deposition.- The lithology of the Carlos sandstone and locally the presence of mollusk casts indicate that the deposition occurred in a shallow sea. Local presence of vertical stem or reed impressions suggest that part of the sandstone was deposited in very shallow water, perhaps in a lagoon which supported plant growth.

Manning formation

Outcrop.- The Manning formation outcrops in a belt ranging from 2 miles in width in the northeast to 3 miles in the southwest part of the Muldoon area.

Topography.- The topography of the Manning formation is almost level to gently rolling.

Lithology.- The Manning formation in this area consists

of chocolate-colored, lignitic clays and shales, and soft, cross-bedded, tuffaceous sand occurring mostly in discontinuous lenses. Many of the sands are silty, lignitic, and limonite-stained on exposed surfaces. In many places they are reworked by irregular fossil burrows (Pl. IV, A) and contain disseminated bentonitic clay pebbles and thin partings or small ferruginous concretions. The sands, clays, and shales occur interbedded or grade into one another. Locally the sediments are very tuffaceous and contain poorly silicified wood. The tuffaceous sand layers project out of creek banks as resistant ledges in many exposures. Hard to indurated light gray, discontinuous lenses of sandstone occur locally. No persistent sandstone beds are present in the area. Small beds of a resistant, grayish-white, very tuffaceous, fine-grained sandstone occur locally between brown-black, very lignitic shale beds. (See Pl. IV, B.) Several feet of chocolate-colored, lignitic shale interbedded with a few discontinuous lenses of indurated, tuffaceous sandstone occur in the base of the Manning.

Stratigraphic relations.- The Manning formation, named by Dumble (1918, p. 176), lies conformably on the Carlos sandstone of the Wellborn formation. The upper boundary of the Manning, in most places, is marked by several feet of lignitic shale and bentonitic silty clay, which are overlain conformably by the cross-bedded tuffaceous sands of the Whitsett

A. Cross-bedded Manning sand riddled by fossil animal burrows; west bank of Black Branch in southwest part of A. F. Hoffman 48-acre tract, northeast part of B. Green survey.

B. Resistant tuffaceous sandstone beds alternating with lignitic shale; Tuttle Creek in south central part of Mrs. J. Browning 63-acre tract, J. M. Ferrill survey.

formation. (See Pl. V, B.) In a few places the Manning-Whitsett contact appears to be gradational. About 2.5 miles S. 30° E. of Muldoon on the west bank of Tuttle Creek in the northwest corner of the Claude Speed 113-acre tract, northwest part of the Noah Carnes survey, a flaggy sandstone showing a few invertebrate fossil casts is present. A quarter of a mile to the southwest along the county road, this flaggy sandstone is overlain by typical, gray, cross-bedded, tuffaceous sands of the Whitsett. Below the flaggy sandstone at this locality are several feet of gray, cross-bedded sands identical in lithology to the Whitsett sands above. However, two-thirds of a mile northeast from the Claude Speed tract, in the northeast corner of Mrs. B. F. Speed 47-acre tract, near the southeast corner of the J. M. Ferrill survey, the gray, cross-bedded sands of the Whitsett rest on chocolate-colored, lignitic clays of the Manning formation and none of the massive, flaggy sandstone is present. (See Pl. V, B.)

Soils and vegetation.- The soils of the Manning formation are for the most part a gray to light brown, sandy to clayey loam. The vegetation consists of post oak, black jack oak, cedar, low shrubbery, and grasses. Most of the improved land supports a cover of grasses and is used for grazing.

Environment of deposition.- The sediments of the Manning formation are for the most part continental deposits interstratified locally with shallow water deposits in the lower

and upper parts of the formation. The lithology and cross-bedded character of many of the strata in the formation suggest deposition under fluviatile conditions. The silicified wood and large amounts of lignitic material in the sediments indicate that there was considerable vegetation present in the area during the time of deposition. The presence of thin, discontinuous lignitic beds suggests that swamp environments prevailed at various times. Thin, flaggy sandstone and thinly bedded shales may represent deposition under lacustrine conditions. The presence of bentonitic material in the Manning sediments proves that volcanic ash falls prevailed during the time of deposition.

Whitsett formation

Outcrop.- The Whitsett formation outcrops in a strip, 0.5 to 0.8 mile wide throughout the area.

Topography.- The topography of the Whitsett is gently rolling.

Lithology.- The Whitsett formation consists of light gray to greenish-gray, lenticular to highly cross-bedded, tuffaceous sands; light gray, bentonitic clays; light brown, sandy clays; tuffaceous, clayey, fine-grained sands; and carbonaceous to lignitic shales. Many of the sands have limonitic laminations parallel to their bedding, and contain light gray, bentonitic, sandy clay pebbles and boulders up

to 3 feet in diameter with their bedding planes oriented at random. (See Pl. VI, A.) These clay pebbles and boulders are undoubtedly fragments of older Whitsett beds which were eroded by river channeling. In Gorham Branch, about 12 feet of a poorly bedded lignite containing small inclusions of a hard, black coal are present. (See Pl. VI, B.)

Stratigraphic relations.- The Whitsett formation, introduced by Dumble (1924, pp. 433-434) and named for the town of Whitsett in Live Oak County, Texas, is the uppermost portion of the Jackson group. The basal cross-bedded sands of the Whitsett (Pl. V, A) lie conformably on the Manning clays although locally the sands show some channeling in the clays. (See Pl. V, B.) In some places the contact is gradational. Bentonitic to carbonaceous clays present at the top of the Whitsett have a wavy upper surface and are overlain disconformably by the basal cross-bedded tuffaceous sands of the Catahoula formation. (See Pl. IX, A.)

Soils and vegetation.- The soils of the Whitsett formation, for the most part, are tan to gray-brown, sandy loams and sands. The vegetation consists of post oak, black jack oak, cedar, low shrubs, and grasses.

Environment of deposition.- The sediments of the Whitsett formation are mostly fluviatile, lacustrine, and lagoonal deposits. The cross-bedded character of the basal Whitsett sand

A. Basal sands of the Whitsett formation. Blackjack Creek in southwest part of Herman Kempe 338.5-acre tract, Martin Smith survey.

B. Manning-Whitsett contact. Tuttle Creek tributary in northeast corner of Mrs. B. F. Speed 47-acre tract, northwest corner of Noah Carnes survey.

A. Sandy clay pebbles and boulders in Whitsett sands; west bank of Blackjack Creek in southwest part of Herman Kempe 338.5-acre tract, Martin Smith survey.

B. Lignite layer visible in center of Manning clay exposure; west bank of Gorham Branch in northeast part of N. R. Cole 136-acre tract, northwest corner of Thos. O. Berry survey.

suggests that these sands were deposited in a shallow water or beach environment. Considerable river channeling or shallow marine conditions prevailed during the Whitsett time as indicated by the cross-bedded character of many of the sands within the formation. The carbonaceous to lignitic shales present locally in the upper part of the formation were probably deposited in a lagoonal environment. Presence of tuffaceous material in the sands and clays suggests the occurrence of frequent volcanic ash falls during Whitsett times.

OLIGOCENE

Catahoula formation

Outcrop.- The Catahoula formation outcrops in a strip 1 to 1.5 miles wide, increasing to 2.2 miles in the south corner of the area.

Topography.- The topography of the Catahoula formation is gently rolling.

Lithology.- The Catahoula formation consists of gray to greenish-gray, cross-bedded, lenticularly to massively bedded, tuffaceous sands; light gray to cream-colored, bentonitic, tuffaceous, sandy clays and clayey sands; and dark gray to greenish-gray, bentonitic, silty clays. Locally the basal sands contain brown to cream-colored, bentonitic clay pebbles and boulders up to 0.5 foot in diameter, rough,

irregular fossil burrows, and silicified logs and stumps up to 3 feet in diameter. (See Pl. VII, A and B.) Thin layers of lignitic sand and shale are present in the formation.

A number of indurated, gray, somewhat rounded, tuffaceous sandstone boulders, up to 3.5 feet in diameter, were found in a bed of loose, dark gray, cross- to massive-bedded quartz sand, approximately 126 feet above the base of the formation. These boulders are located in the head of a deep gully on the Bamache land immediately south of the center of the south line of the M. H. Brown 136-acre tract, northwest corner of Thos. O. Berry survey. The boulders were probably derived from the basal indurated tuffaceous sandstone of the Catahoula formation and transported by streams to their present position.

Several feet of a gray, cross-bedded, calcareous sandstone containing grayish-white calcareous nodules (Pl. VIII, A) are exposed 2.9 miles S. 35° E. of Muldoon, at the junction of the Flatonia-La Grange county road and the Muldoon-La Grange road. Eastward along the road there are calcareous sandy clays above the sandstone. This calcareous sandstone is about 40 feet below the Catahoula-Oakville contact, which is exposed approximately 1000 yards due east at the intersection of the road and the west line of the Thos. O. Berry survey. Renick (1936, p. 61) states that this is the

A. Silicified stump. Chita sand in Black Branch tributary, C. W. Faulkerson 260-acre tract, northeast part of B. Green survey.

B. Silicified log. Chita sand in Black Branch tributary, C. W. Faulkerson 260-acre tract, northeast part of B. Green survey.

A. Calcareous sandstone of the Catahoula formation; north ditch at Muldoon-La Grange and Flatonia-La Grange county road junction.

B. Silty clay containing concretionary layers of the upper part of the Catahoula formation; small creek in southwest corner of Theo. Hinze 404-acre tract, northwest corner of S. F. Knight survey.

first occurrence of calcareous sandstone in the Catahoula formation to the southwest of Grimes County. Southward from this locality the formation contains gray, calcareous, fine-grained sands and clays lower in the section and calcareous clays containing calcareous sandstone lenses in the upper portions. Thin, irregular, concretionary, calcareous beds and irregular, calcareous stringers are interbedded with the sands and clays in the upper Catahoula (Pl. VIII, B) on the Hinze and Kopca land in the northwest corner of S. F. Knight survey.

Stratigraphic relations and dip.- The Catahoula formation, proposed by Veatch (1906, p. 42) and named for Catahoula Parish, Louisiana, rests unconformably on the underlying Whitsett formation. Miss Ellisor (1933, p. 1311) reported that in Fayette County south of Muldoon and east for a distance the Whitsett formation is completely overstepped by the Catahoula. In support of this statement, Ellisor's "Section south of Muldoon" (1933, p. 1330, fig. 7) shows the Catahoula formation resting directly on the Manning formation and the Whitsett formation removed by erosion. However, Renick (1936, p. 66) states that the Catahoula formation rests here on the Whitsett formation and that this relation may have been misinterpreted by Ellisor because the Yuma sandstone grades out laterally or has been removed by stream channeling at the base of the Whitsett

formation.

The stratigraphic relations at the base of the Catahoula formation shown in Ellisor's section are presumed by Renick (1936, p. 66) to exist in the west part of the E. Berry 112-acre tract, Noah Carnes survey, but he states that to the east along the south side of this tract typical Whitsett beds are present. The writer found the basal Catahoula sand overlying the Whitsett clays in the southeast corner of the E. Berry 112-acre tract and the beds to the west along the south line of the tract to be typical Whitsett beds as described by Renick.

The Chita sand, introduced by Plummer (1932, pp. 715-716), is up to 26 feet in thickness in this area. Plummer included in the Chita sand the basal sands of the Catahoula formation exposed near the town of Chita in Trinity County, which extend as far southwest as the Guadalupe River in Gonzales County, Texas. In the Muldoon area, gray, cross-bedded to lenticular Chita sands rest on an undulating surface of the Whitsett bentonitic clays. (See Pl. IX, A.)

The upper, dark gray, bentonitic clays of the Catahoula formation are overstepped by several feet of the dark gray, cross-bedded calcareous Oakville sand and sandstone. The contact is marked in most places by a low cuesta supported by the calcareous Oakville sands rising above the Catahoula clays. (See Pl. IX, B.) Renick (1936, p. 67) states that

A. Whitsett-Catahoula contact. Black Branch tributary near center of west boundary of C. W. Fulkerson 260-acre tract, northeast part of B. Green survey.

B. Oakville cuesta. Basal Oakville sand overstepping Catahoula clay in northwest part of L. L. Neisner 74-acre tract, Thos. O. Berry survey.

southwestward from Brazos County the Catahoula is gradually overstepped by the Oakville formation, and from northern Fayette County southwest only the lower part of the Catahoula formation is exposed. In the southeast corner of the area mapped, the outcrop width of the Catahoula formation increases to 2.2 miles. This is probably due to the failure of the Oakville to overstep the Catahoula formation in this particular area.

The dip of the lower part of the Catahoula formation in the Muldoon area is about 100 feet per mile. However, no persistent beds are present on which to determine the dip accurately. In the southeast part of the area, where the Catahoula outcrop has the largest areal extent, elevations were taken on the basal sand bed of the Oakville formation, immediately above the contact, and the dip was determined to be 68 feet per mile.

Soils and vegetation.- The Catahoula formation produces a gray to light brown, sandy loam in the lower portion and a gray to black loam in the upper portion. Vegetation consists of post oak, black jack oak, cedar, and grasses. Some of the land along the eastern edge of the outcrop belt is open and in cultivation. Corn, cotton, and sorghum are the principal crops raised.

Age.- The Catahoula formation was regarded as Oligocene in age by Veatch (1906, p. 42) who first proposed this

name for the lower sandstone member of Hilgard's (1860, pp. 147-154) Grand Gulf group, which overlies the Vicksburg group (Oligocene) in Mississippi and Louisiana. Berry (1916, pp. 227-251) referred the basal beds of the Catahoula formation in east Texas to the Oligocene and described a few plant fossils. Deussen (1924, p. 95, Pl. I) mapped the Catahoula formation southwestward to central Fayette County, Texas, as Upper Oligocene. Bailey (1926) proposed the Gueydan formation for strata of typical Catahoula lithology in south Texas and assigned it to the Upper Oligocene. The reason the Catahoula formation was then regarded as Upper Oligocene was that it overlies the Lower Oligocene or Vicksburg group in Mississippi and Louisiana and underlies strata containing Miocene vertebrate fossils.

Woodring (1928, p. 90) drew the lower Miocene boundary at the base of the Tampa limestone. The Tampa limestone is regarded by stratigraphic workers to be more or less contemporaneous with the Catahoula sandstone east of Louisiana. Moody (1931, pp. 546-547) classified the Catahoula formation as Miocene. He stated that in East Texas and Louisiana gentle downwarping of the Coastal Plain toward the west permitted the complete overlapping of the marine Oligocene deposits by the sands and clays of the Miocene Catahoula formation.

On the basis of a brackish water and marine faunule discovered in Fayette County, Texas, and identified by

F. S. MacNeil and Julia Gardner, Leslie Bowling (1933, pp. 534-535) assigned to the Upper Eocene the lower 30 feet of what was then considered to be the Catahoula formation. The remaining part of what had been considered as the Catahoula formation, Bowling tentatively assigned to the Oligocene, or Miocene, or both.

Weeks (1933, p. 456) assigned the Catahoula formation of Texas to the Miocene on the basis of a jaw bone of an extinct rhinoceros, Coenopus, found in Washington County, Texas, because this rhinoceros bone was regarded as of probable Middle or Upper Miocene age by J. W. Gidley of the United States National Museum.

Blanpied and Hazzard (1935, pp. 571-575) discovered field evidence that there are marine strata below the typical Catahoula cross-bedded sands and clays in Wayne County, Mississippi. On the basis of lithology they divided these marine strata into three members; the Bucatunna (nonmarine) and the Lower and Upper Chickasawhay (marine), named in ascending order. They found a widespread erosional break at the base of the Bucatunna member which overlaps and truncates the underlying Vicksburg strata of Oligocene age. For this reason they referred the Bucatunna, Chickasawhay, and Catahoula sandstone to the Miocene. They also correlated the Tampa limestone with the Bucatunna and Chickasawhay. In conjunction with this field evidence, a study of the faunas

of the Lower and Upper Chickasawhay by H. V. Howe and James McGuirt led to the assignment of these strata to the Miocene. Since Blanpied and Hazzard's work was published many stratigraphers have followed their correlation and placed the Catahoula formation of Texas in the Miocene.

This age assignment of the Catahoula formation of Texas to the Miocene is in direct contradiction to the vertebrate paleontologic evidence in Texas. Since Deussen (1924) the jaw bone of Coenopus has been known and is the only vertebrate remain known from the Catahoula. This jaw bone has recently been studied by H. E. Wood and A. E. Wood, who are experts in fossil rhinoceros of North America. They clearly state (1937, p. 129) that Coenopus is restricted to the Oligocene of North America. Hence it is necessary to assign the Catahoula formation of Texas to the Oligocene.

Environment of depositon.- The Catahoula formation is a series of fluviatile and lacustrine deposits which contain an abundance of volcanic material. The Catahoula was deposited on a relatively flat plain at the time of one of the most important periods of volcanic activity in west Texas and in the western United States. Bailey (1926, p. 164) believed that one center of volcanic activity was probably located in southwestern McMullen or western Duval County, Texas. This volcanic material was brought into the Catahoula depositional area by way of dust clouds and streams.

The sudden influx of lime nodules and pebbles into the Catahoula sediments suggests that there was an uplift in the present Edwards Plateau region and possibly along the Balcones fault line. As a result of this uplift, the gradients of the streams may have been increased, thus making it possible for a rapid transportation of the lime material into the Catahoula area. These streams may also be responsible for the presence of the logs and stumps now silicified in the Catahoula sands.

The scarcity of lignitic material present in the Catahoula sediments suggests that very little vegetation was present in the area during the period of deposition or that the vegetation failed to become entombed. This may have been due to the presence of the acidic volcanic material in which plant life was unable to thrive or could not be preserved once it was enclosed in the sediments.

MIOCENE

Oakville formation

Outcrop.- The Oakville formation outcrops in the southeast part of the Muldoon area. A strip ranging up to 1 mile in width of the lower Oakville is included.

Topography.- The lowermost beds of the Oakville formation form a low sandy cuesta, which becomes inconspicuous in places. In general, the lower Oakville topography

is rolling and dissected by erosion of the soft clays.

Lithology.- The lower Oakville formation consists of gray, poorly bedded, calcareous clays with some thin lenses of cross-bedded, calcareous sands. Locally interbedded with the calcareous clays and sands, there are gray, calcareous, sandy clays, greenish-gray clays, and light gray, tuffaceous sands similar in lithology to the underlying Catahoula formation.

Stratigraphic relations and dip.- The Oakville formation, first differentiated from Penrose's (1890, pp. 47-50) Fayette Beds by Dumble (1894, pp. 556-559) and named for the town of Oakville, Live Oak County, Texas, overlies the Catahoula unconformably. The contact in most places is marked by a low cuesta of several feet of gray to brownish-gray, calcareous sand of the Oakville formation overstepping the tuffaceous clays of the Catahoula formation. The contact is clearly exposed 0.2 mile northwest of the northeast corner in the L. L. Neisner 74-acre tract, Thos. O. Berry survey. (See Pl. IX, B.) Fragments of reworked Cretaceous invertebrate fossils weather out of the basal Oakville sand at this locality. Where the basal Oakville sand is absent, the Oakville clays can be distinguished from clays of the Catahoula formation by their darker color, less tuffaceous material, and greater calcareous content.

The dip of the lower Oakville formation, calculated from elevations taken on the basal sand, is about 68 feet

per mile.

Soils and vegetation.- The lower Oakville formation weathers to a dark gray to black clay loam. Most of the Oakville surface is open prairie and is cultivated or used for grazing. Corn and cotton are the principal crops. The Oakville forms the western boundary of the Washington Prairie, first recognized and named by Hill (1901, p. 408). In the vicinity of the lower boundary and along some creeks, the Oakville soils are more sandy and support small scattered patches of post oak, black jack oak, and a few cedars.

Age.- On the basis of the determination of fossil bones from Washington County, Texas, by Leidy (1861, p. 416), and the discovery of extensive Miocene strata in Texas by Shumard (1863, pp. 140-141), Dumble (1894, pp. 556-559) assigned the Oakville formation to the Miocene. Later discoveries and identifications of vertebrate bones from the Oakville formation by Dumble (1903, p. 957; 1918, p. 237), Hays (1924, pp. 1-19), Simpson (1933, pp. 79-121), A. E. Wood and H. E. Wood (1937, pp. 129-146), and H. E. Wood (1941, pp. 1-48, Pl. I) indicate that the formation is Middle and Upper Miocene in age. On the basis of their original investigations and significant evidence obtained by other workers, C. W. Cooke, Julia Gardner, and W. P. Woodring (1943, pp. 1713-1724, Chart No. 12) placed the Oakville formation in the Middle Miocene.

Environment of deposition.- The sediments of the lower

Oakville formation were deposited by streams on a relatively flat, featureless coastal plain along the border of a sea. The presence of calcareous material and reworked Cretaceous fossils in the Oakville deposits indicates a strong uplift of the Cretaceous areas of central Texas at the beginning or during Oakville time. Volcanic material also continued to be deposited in the lower Oakville formation.

HOLOCENE

Alluvium

Distribution.- Nearly all the creeks and branches in the Muldoon area have narrow flood plains. However, only the flood plains of Buckners Creek, Pin Oak Creek, and Gorham Branch in the northeast part of the area are shown on the map (Plate I). The flood plain of Buckners Creek immediately west of the Buckners Creek Railroad Bridge attains a maximum width of about 0.1 mile.

Composition.- The alluvial deposits consist of light gray to black, poorly bedded, sandy or silty clay loams, usually with an admixture of decaying vegetation. In parts of the Buckners Creek flood plain, small pools of stagnant water are present throughout the year. The soil along the banks of the pools is a usually sticky black clay, which cracks in dry weather. The alluvial deposits of the flood plains are derived from soft, nonresistant rocks.

STRUCTURE

Regional Structure

The regional dip in this area is towards the Gulf of Mexico, which is to the southeast. The angle of dip ranges from 1° 24' or 129 feet per mile for the Wellborn formation to 0° 44' or about 68 feet per mile for the lower Oakville formation.

The strata are gently inclined to the southeast, forming a homocline.

Local Structure

The Jackson and Catahoula formation become higher structurally and apparently thinner across the area to the southwest. This feature conforms with the Flatonia nose, designated by Renick (1936, pp. 85-86) as a regionally high area in which the formations are thinner because of gradual uplift and diminished deposition during Jackson time.

Faulting.- The faulting in the Muldoon area is restricted to minor normal faults in the Carlos sandstone outcrop. The two faults indicated on Plate I are based on outcrops and have the downthrow to the northwest. The fault located 1.2 miles N. 25° E. of Muldoon has a throw of about 7 feet and strikes N. 65° E. The fault fracture itself

is visible in the face of the northwest-facing Wellborn erosional scarp. (See Pl. XI, A.) Boulders of the Carlos sandstone, apparently derived from the upturned edge of the bed, are exposed at the surface on the upthrown side of the fault to the northeast as far as the Muldoon-West Point county road. Northeast of the road, the fault dies out or possibly passes into a monoclinal fold. The other fault, located 2.4 miles S. 45° W. of Muldoon, has a throw of about 10 feet and strikes N. 85° E. (See Pl. X.) This fault is based on the presence of a low south-facing scarp upheld by the Carlos sandstone on the downthrown side and the absence of the massive sandstone on the upthrown side. Minor amounts of angular fragments of the sandstone with occasional secondary silica coatings on flat surfaces are present along the trace of the fault. At least two or three other faults seem to be present in the Carlos sandstone outcrop. These faults are based only on the low re-entrant erosional features present in the Wellborn cuesta. Two of these apparent faults are located immediately west-southwest of Muldoon; the third is immediately west of the Jesse Boehnke house, 1.2 miles southwest of Muldoon.

The faults in this area produce low, short, northeast-trending re-entrant erosional features in the Wellborn cuesta. These low topographic features trend in a direction opposite to the drainage pattern immediately to the west of the cuesta.

Plate X

Aerial view of fault line trace trending N. 85° E., west of Farm road No. 154, 2.4 miles southwest of Muldoon, Texas.

A. Fault exposed in westward-facing cuesta of Wellborn sandstone, 0.4 mile west of Wrightman Crossing, M. Muldoon survey.

B. Abandoned Carlos sandstone quarry, 0.4 mile west of Wrightman Crossing, M. Muldoon survey.

Folding.- The extent of folding in this area is restricted to slight drag folds at the fault northeast of Muldoon. Evidence of the drag folds is indicated on Plate I by the elevations taken on the Carlos sandstone outcrop at the fault zone.

Elevation of geologic formation boundaries.- The elevations of formation boundaries in the Muldoon area listed below are entered on the geologic map, Plate I. Most of the elevations were obtained with an aneroid barometer and corrected for temperature. A few of the elevations were obtained with a level. The elevations under each heading are listed progressing from the northeast to the southwest.

Elevation of geologic formation boundaries

Description	Feet above sea level
Top of Yegua clay:	
County road, contact exposure in east side of ditch 1.0 mile northeast of Henson and Pitman cemeteries, east central part of M. Muldoon survey	371
County road, contact exposure in east ditch 1.35 miles south of Parkerville north part of F. A. Bettinger survey	371
County road, contact exposure in west ditch 0.85 miles northwest of Cherry homestead, northeast part of Wm. H. Walton survey	373

Description	Feet above sea level
Top of Wellborn formation:	
Wellborn scarp, top of Carlos sandstone 0.5 mile northeast of iron bridge over Buckners Creek on Muldoon-West Point road, northeast part of M. Muldoon survey	327
Wellborn dip slope, top of Carlos sandstone 150 yards south of railroad bridge over Buckners Creek, northeast part of M. Muldoon survey	296
Wellborn dip slope, top of Carlos sandstone outcrop north of bridge on county road east of Wrightman's Crossing, M. Muldoon survey	331
Old road cut, top of Carlos sandstone outcrop alongside and on west side of Muldoon-West Point county road, 800 feet southeast of iron bridge over Buckners Creek, 2.4 miles northeast of Muldoon, Texas, east part of M. Muldoon survey	331
Wellborn scarp, top of Carlos sandstone outcrop 0.15 mile northeast of abandoned house and north of fault, middle of M. Muldoon survey	353
Wellborn scarp, top of Carlos sandstone outcrop west of abandoned house and north of fault, middle of M. Muldoon survey	352
Wellborn scarp, top of Carlos sandstone outcrop southwest of abandoned house and north of fault, M. Muldoon survey	359
Wellborn scarp, top of Carlos sandstone outcrop north of abandoned rock quarry and fault, M. Muldoon survey	362
Wellborn scarp, top of Carlos sandstone outcrop near west edge of abandoned rock quarry and west of fault, M. Muldoon survey	361

Description	Feet above sea level
Top of Wellborn formation, continued:	
Wellborn scarp, top of Carlos sandstone outcrop near south edge of abandoned rock quarry north of fault, M. Muldoon survey ...	361
Wellborn scarp, top of Carlos sandstone outcrop near east edge of abandoned rock quarry north of fault, M. Muldoon survey ...	355
Wellborn scarp, top of Carlos sandstone outcrop immediately south of fault, M. Muldoon survey	362
Wellborn scarp, top of Carlos sandstone outcrop south of fault, M. Muldoon survey	358
Wellborn scarp, top of Carlos sandstone outcrop south of fault, M. Muldoon survey	353
Wellborn scarp, top of Carlos sandstone outcrop south of fault and due west of the old Smith house, M. Muldoon survey	356
Wellborn scarp, top of Carlos sandstone outcrop south of fault and southwest of the old Smith house, M. Muldoon survey	354
Wellborn scarp, top of Carlos sandstone outcrop south of fault and north of private road descending over scarp to abandoned house, M. Muldoon survey	349
Wellborn scarp, top of Carlos sandstone outcrop west of shallow abandoned rock quarry and Muldoon Negro Church, M. Muldoon survey	355
Wellborn scarp, top of Carlos sandstone outcrop east of shallow abandoned sand pit, southwest corner of M. Muldoon survey	377
Wellborn scarp, top of Carlos sandstone outcrop on south edge of abandoned rock quarry north of fault, southwest corner of W. M. Evans survey	390

Description	Feet above sea level
Top of Wellborn formation, continued:	
Wellborn cuesta, top of Carlos sandstone outcrop, southeast corner of F. A. Bettinger survey	380
Live Oak Creek tributary, top of Carlos sandstone outcrop in head of deep gully north of large water tank, northeast part of J. Viven survey	380
Top of Manning formation:	
Gorham Branch tributary, contact exposure in banks of first small tributary south of county road, south part of J. Bartlett survey	330
Blackjack Creek, contact exposure in north bank, southwest part of M. Smith survey	329
Tuttle Creek tributary, contact exposure below top of small water fall in tributary, northwest corner of Noah Carnes survey	377
Tuttle Creek tributary, contact exposure in east bank, northwest corner of Noah Carnes survey	379
Tuttle Creek, contact exposure in west bank, northwest corner of Noah Carnes survey	362
Black Branch tributary, contact exposure below top of small water fall in tributary, northeast part of B. Green survey	359
Top of Whitsett formation:	
Gorham Branch, contact exposure near top of water fall in mouth of tributary at junction with branch, northwest corner of Thos. O. Berry survey	355

Description	Feet above sea level
Top of Whitsett formation, continued:	
Emerson Creek, contact exposure in north bank, near center of east line of David Berry survey	379
Tuttle Creek tributary, contact exposure in head of deep narrow tributary west of Speed water tank, northwest corner of Noah Carnes survey	386
Black Branch tributary, contact exposure in south bank of tributary, northeast part of B. Green survey	370
Top of Catahoula formation:	
Muldoon-La Grange county road, contact exposure at base of north-facing cuesta west of road, northwest part of Thos. O. Berry survey	447
Muldoon-La Grange county road, contact exposure in north ditch, corner of E. Y. Kean survey	456
Tributary of West Fork of Navidad River, base of Oakville in north bank of tributary, south part of Noah Carnes survey	403
West Fork of Navidad River, base of lower Oakville in east bank, west part of S. F. Knight survey	383
Tributary of West Fork of Navidad River, base of lower Oakville in east bank of tributary, west part of S. F. Knight survey	382
Oakville cuesta, base of lower Oakville in deep north county road ditch near base of low east-facing cuesta, southeast part of B. Green survey	434

ECONOMIC GEOLOGY

Lignite

Lignite-bearing beds up to 2.5 feet thick occur in the Manning and Whitsett formations in the Muldoon area. The beds are exposed in Gorham Branch in the northwest corner of Thos. O. Berry survey, Emerson Creek in the northeast part of David Berry survey, and Alligator Creek in the north central part of Ben Green survey. In all cases the lignite layers are too thin and impure to be commercially valuable.

Building stone

The hard gray Carlos sandstone of the Wellborn formation cropping out in the area has been quarried extensively in the past. (See Pl. XI, B.) The hard rock was used for buildings, building foundations, and chimneys, but most of it went into the construction of the Galveston sea wall. The abandoned rock quarries are shown on Plate I.

Road material

Materials suitable for road surfacing have been obtained from small pits on the outcropping Catahoula formation. (See Pl. XII, B.) The material consists of hard

A. Aerial view of the Sylver and Wrightman clay pit, 4.9 miles northwest of Muldoon, Texas

B. Catahoula sandstone pit, alongside county road corner 0.75 mile due north of Old La Grange and Flatonia-La Grange county road junction.

tuffaceous clayey sandstone. The material is wear-resistant and contains sufficient amounts of binding ingredients to stablize road beds.

Bleaching clay

Bleaching clay deposits occur in the Yegua and Caddell formations in the Muldoon area. Mining of the clays at the present time is being carried on by the Baroid Clay Company from the Sylver and Wrightman clay pit northwest of Muldoon, and by the Mills-White Clay Company from the southernmost Cherry clay pit southwest of Muldoon. The untreated clay is shipped by rail to Houston, Texas, for processing. Several other clay pits are shown on Plate I, but these are now abandoned.

LABORATORY ANALYSES
OF BASAL CADDELL SAND

Sampling and Laboratory Treatment

A series of samples beginning at the base of the Caddell formation and numbered A5 through A17 were collected from the measured Section No. 28 (fig. 3). A small area on the outcrop face was scraped clean of weathered surface material and approximately two pounds of sand sample, as unweathered and representative as possible, were collected at each spot. Samples were taken immediately above the contact and continued upward through 27.3 feet of the section. As illustrated in Figure 3, samples were collected from approximately the middle of sand units free of thin layers of interbedded clay. The interval of spacing was smaller in the basal 4 feet due to the occurrence of more interbedded clay layers and apparent variation in the sand units themselves. Four samples were collected from the underlying clay formation but are not involved in this work.

A mechanical analysis of each sample was made by standard methods of sieving following a process of decantation by which all grade sizes below 1/32 mm. of the sediment were removed. Bromoform was used on whole samples to separate the light and heavy minerals. The heavy residue

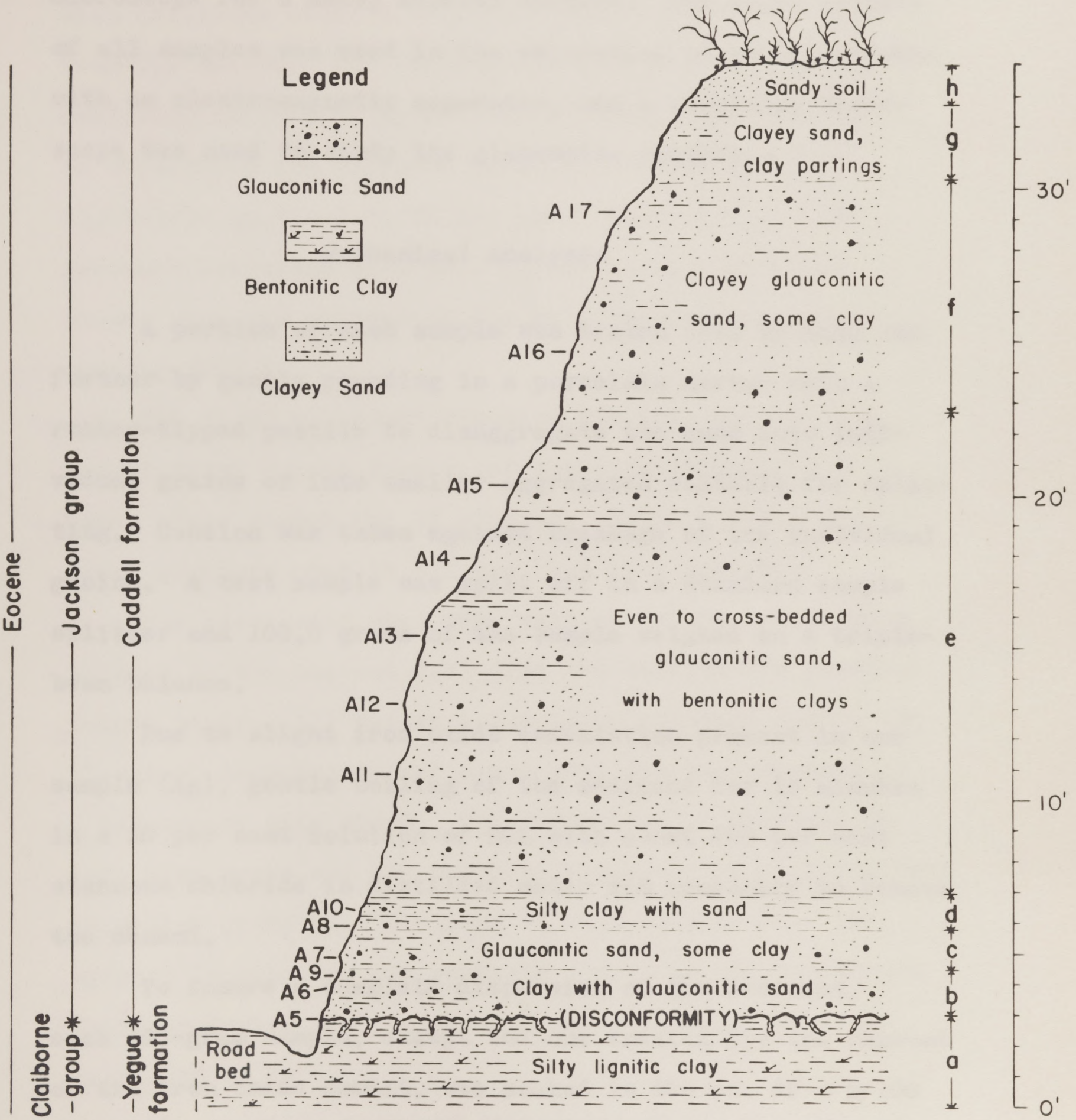

Figure 3. Yegua-Caddell contact in east bank of county road cut, 1.72 miles northwest from the Muldoon post office

from several samples was then analyzed under a polarizing microscope for a heavy mineral content. The light residue of all samples was used in the separation of the glauconite with an electromagnetic separator, and a binocular microscope was used to study the glauconite content.

Mechanical Analyses

A portion of each sample was broken down by hand and further by gently pounding in a porcelain mortar with a rubber-tipped pestile to disaggregate the sand into individual grains or into smaller aggregates suitable for splitting. Caution was taken against breakage of the individual grains. A test sample was split off in a standard sample splitter and 100.0 grams of the sample weighed on a triple-beam balance.

Due to slight iron oxide cementation present in one sample (A_8), gentle boiling of the sediment for 15 minutes in a 20 per cent solution of HCL with about 100 per cent stannous chloride in distilled water was necessary to remove the cement.

To insure a complete dispersion of the sediment, each 100-gram sample, except the one treated for the removal of the iron oxide cement, was soaked in 100 cc. of a N/100 sodium oxalate solution for approximately 24 hours. At the end of this period the sample plus all the solution was

transferred to a 1000 cc. graduated cylinder and filled with distilled water to a height slightly over 15 inches from the bottom. The decantation method of mechanical analysis, introduced by Wentworth (1926), was followed in separating the sediment into the "1/128-1/64 mm.", "1/64-1/32 mm." and "1/32 mm. plus" grade sizes. The sediment fractions were then placed in an electrical blower oven and allowed to dry at a temperature not exceeding 100° C.

The "1/32 mm. plus" fraction was then placed in a set of Tyler screen sieves and shaken mechanically in a Rotap sieve shaker for 10 minutes. Table 1 indicates the sieve openings used in all the sand size analyses.

The sieve separates were weighed on the triple-beam balance to the nearest 0.01 gram and bottled for possible future study. All weight information obtained during the cleaning, decantation and sieve analyses was recorded on a laboratory data sheet. The percentage of material in each size grade and the cumulative percentage of finer than each size grade were recorded on this data sheet. The weights in grams of the separate fractions in each sample obtained during the decantation and sieve analyses are tabulated in Table 2.

The quartile measures introduced by Trask (1932, pp. 67-76) involving the use of the first quartile (Q_1), the

Table 1.- Wentworth grade scale, corresponding Tyler sieve openings, and grade size

Wentworth Grade Scale (mm)	Tyler Screens (mm)	Grade Size (mm)
	0.701	1.000-0.707
1/2	0.495	0.707-0.500
	.351	0.500-0.354
1/4	.246	0.354-0.250
	.175	0.250-0.177
1/8	.124	0.177-0.125
	.088	0.125-0.088
1/16	.061	0.088-0.062
1/32	Pan	0.062-0.044

median (Md), and the third quartile (Q_3), and Wentworth's grade scale (1922, pp. 377-392) were used in analyzing the sedimentary data on the sands. The Wentworth grade scale is given in Table 3. Cumulative curves, introduced by Krumbein (1936, pp. 98-111), were plotted on semi-logarithmic graph paper from the cumulated weight percentage data of the individual samples as illustrated in figures 4-7. The first and third quartiles and median diameter were read directly from the cumulative curves of each sample and are tabulated in Table 4.

The first quartile (Q_1) is defined as that diameter

Table 2.- Size distribution of mineral grains in basal Caddell sand samples

Sample	0.701 (mm)	0.495 (mm)	0.351 (mm)	0.246 (mm)	0.175 (mm)	0.124 (mm)	0.088 (mm)	0.061 (mm)	Pan	1/32-1/64	1/64-1/128
A_{17}	-	0.04	0.07	0.30	2.41	35.00	43.15	7.48	2.80	1.70	3.05
A_{16}	-	0.02	0.06	0.13	1.41	35.37	45.63	8.13	2.71	1.28	2.06
A_{15}	-	0.04	0.09	0.25	2.36	42.83	37.76	6.58	3.25	2.28	1.45
A_{14}	-	0.03	0.10	0.27	3.55	53.73	31.23	4.21	2.52	1.93	1.54
A_{13}	-	0.01	0.03	0.13	2.34	43.00	38.99	6.43	3.40	2.62	1.92
A_{12}	-	0.01	0.10	0.35	5.85	42.60	36.68	6.28	1.95	2.65	1.84
A_{11}	-	-	0.04	0.15	9.21	54.55	25.80	4.03	1.40	2.35	1.59
A_{10}	-	-	0.02	0.04	5.52	57.30	24.83	4.93	2.90	2.20	1.57
A_{8}	-	0.04	0.14	0.94	2.92	8.38	30.24	20.86	14.76	7.05	5.46
A_{7}	0.03	0.12	0.24	2.76	52.75	23.18	8.00	2.30	2.08	2.45	2.71
A_{9}	-	-	0.10	0.50	10.58	54.90	24.30	2.76	1.33	1.55	2.00
A_{6}	-	0.02	0.05	0.21	8.36	52.24	25.70	4.85	2.03	2.06	2.53
A_{5}	-	0.02	0.10	0.88	4.12	42.52	36.70	6.95	2.61	1.79	2.31

Table 3.- Wentworth's size classification

Grade Limits (Diameter in mm)	Term
256	Boulder
256-64	Cobble
64-4	Pebble
4-2	Granule
2-1	Very coarse sand
1-1/2	Coarse sand
1/2-1/4	Medium sand
1/4-1/8	Fine sand
1/8-1/16	Very fine sand
1/16-1/256	Silt
1/256	Clay

which has 25 per cent of the distribution smaller than itself and 75 per cent larger than itself. It is established from the cumulative curve by reading the diameter value which corresponds to the point of intersection between the 75 per cent line and the cumulative curve. The third quartile (Q_3) is that diameter which has 75 per cent of the distribution smaller than itself and 25 per cent larger than itself. It is established from the cumulative curve by reading the

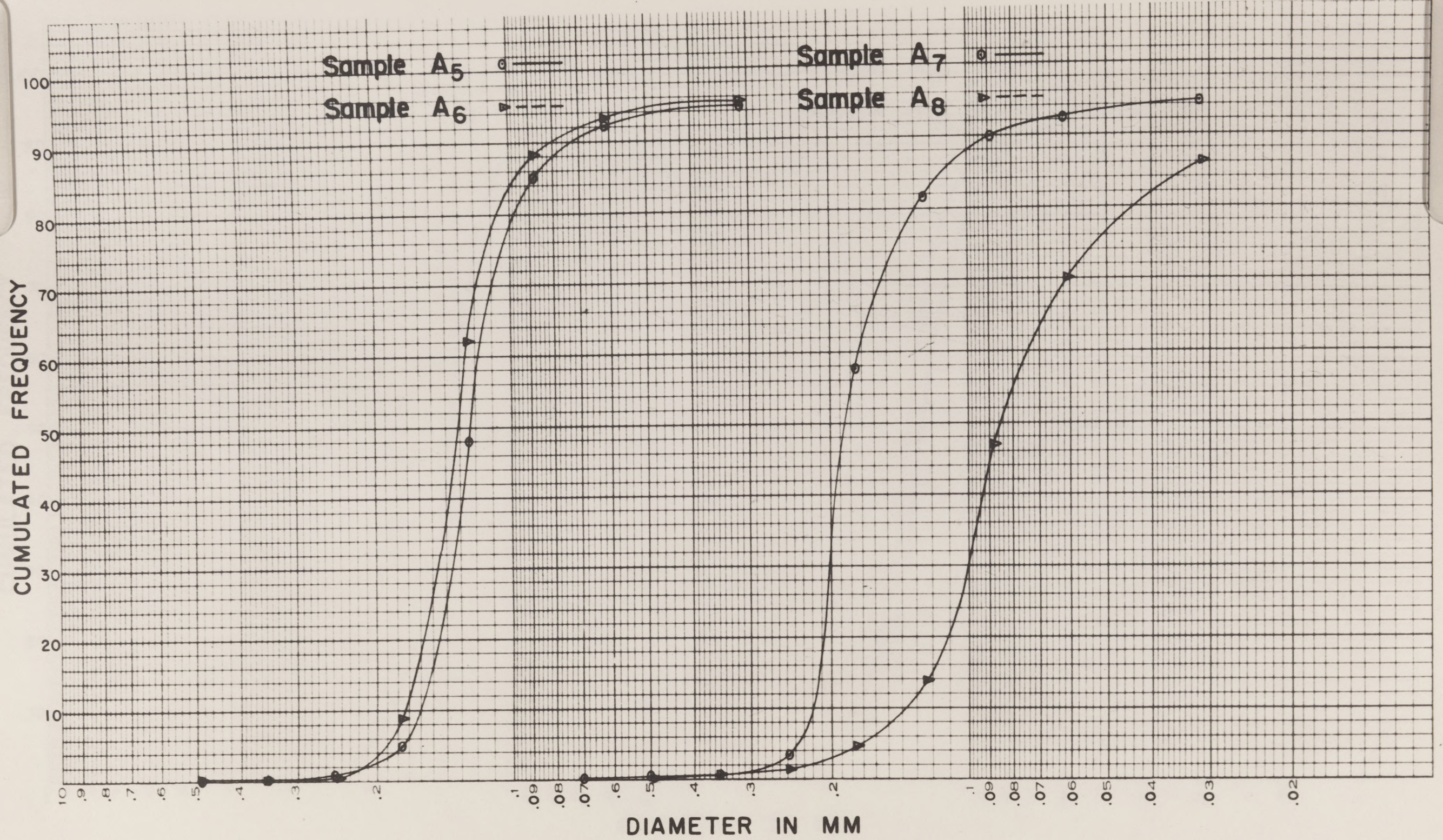

Figure 4. Cumulative curves of basal Caddell sand

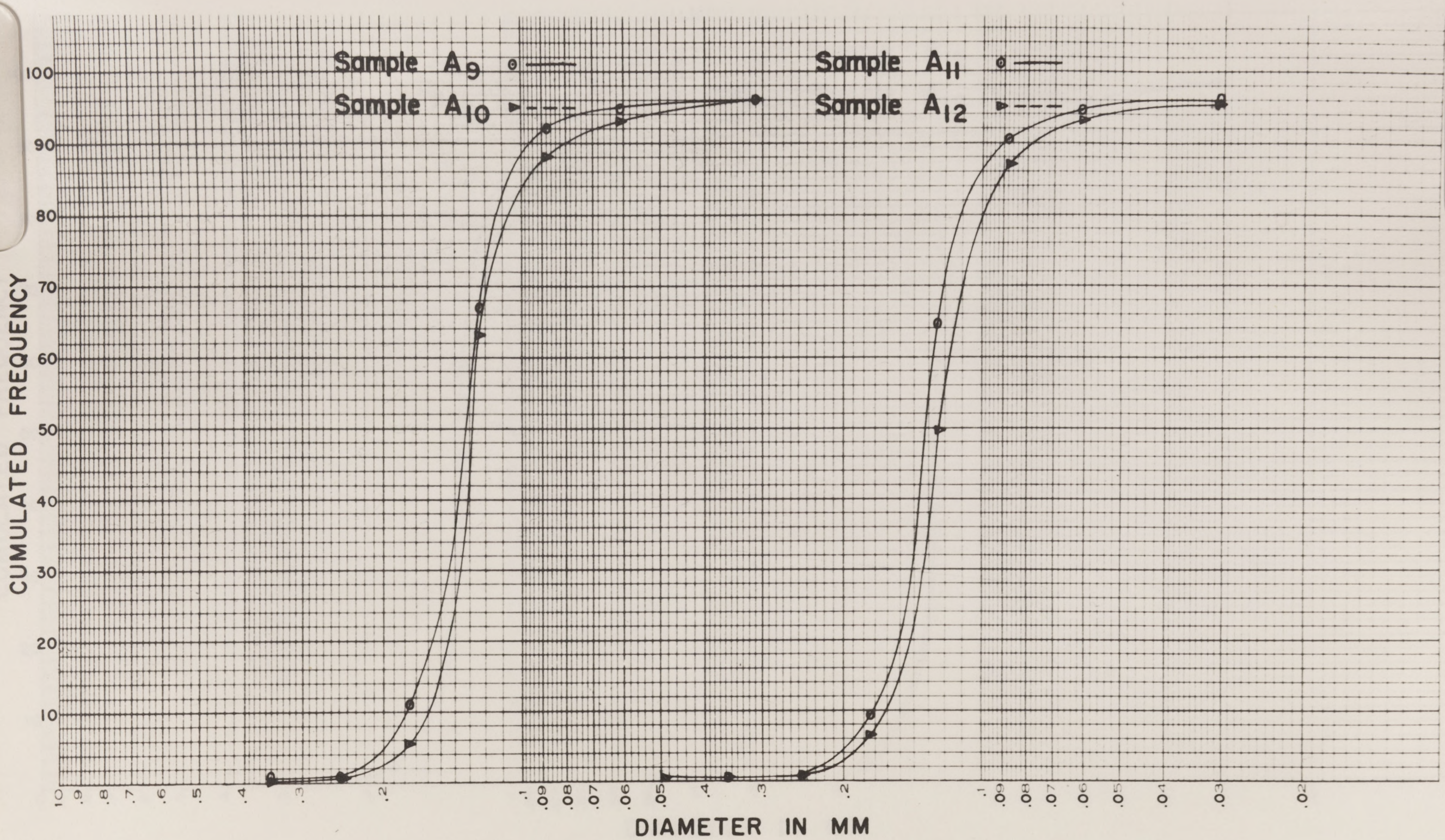

Figure 5. Cumulative curves of basal Caddell sand

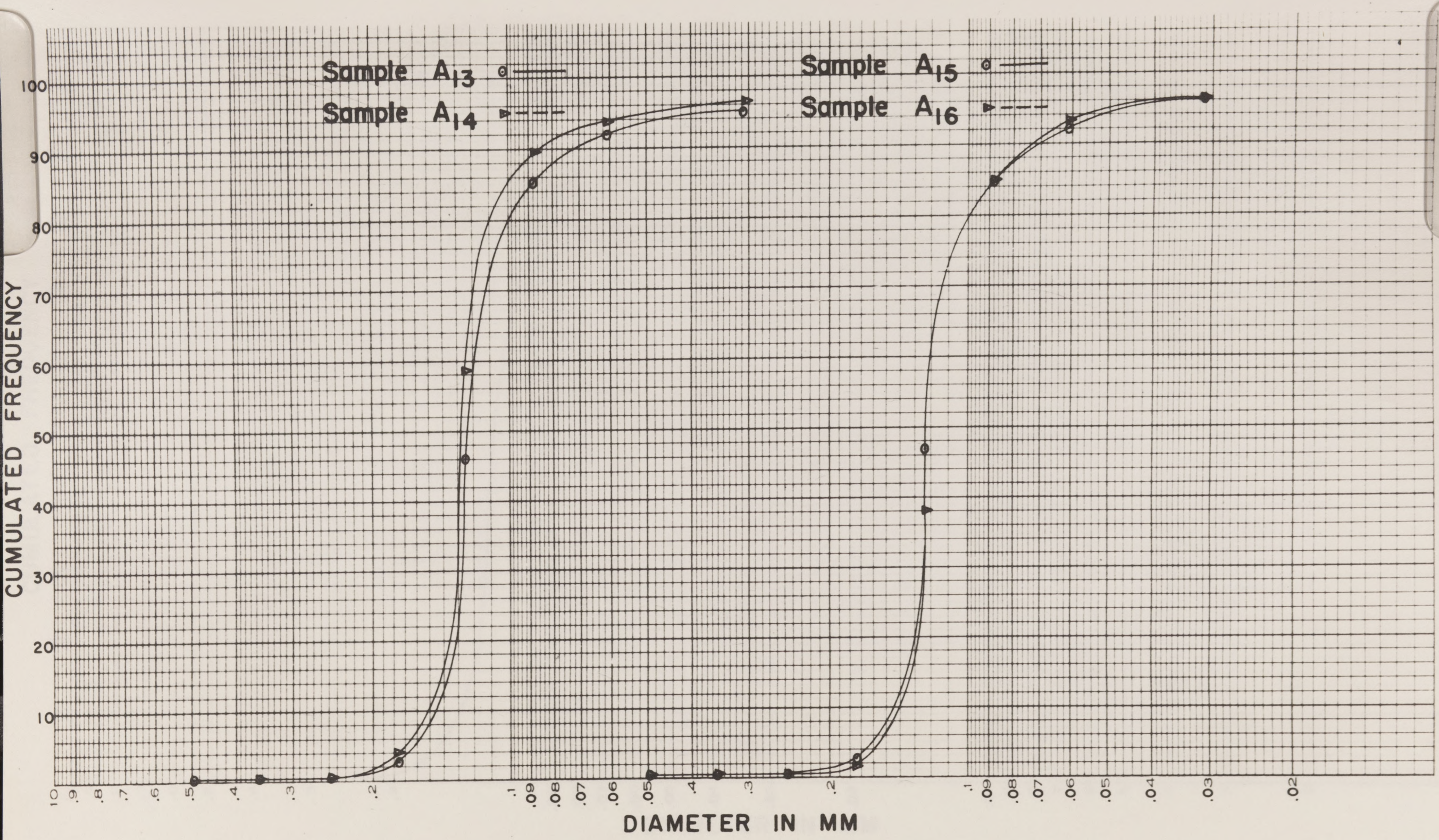

Figure 6. Cumulative curves of basal Caddell sand

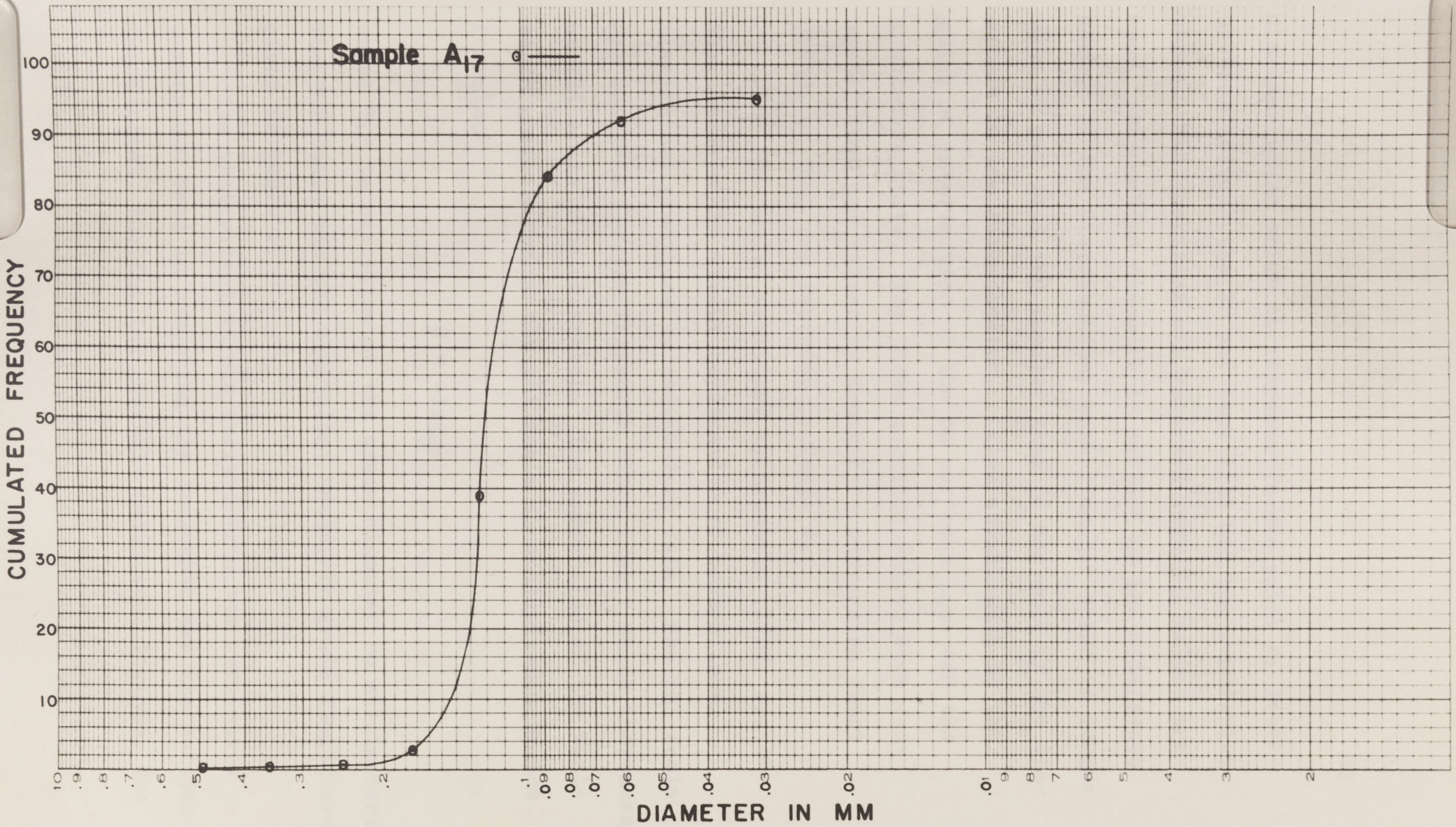

Figure 7. Cumulative curve of basal Caddell sand

diameter value which corresponds to the point of intersection between the 25 per cent line and the cumulative curve. The quartiles are reversed when phi values are used. The median diameter is defined as the middlemost member of the distribution; that diameter which is larger than 50 per cent and smaller than 50 per cent of the diameters in the distribution. It is established by the point of intersection of the 50 per cent line and the cumulative curve. The three quartile values were converted into phi values by Krumbein's conversion chart (1938, p. 244) and recorded in Table 4.

The phi scale, developed by Krumbein (1936, pp. 35-47), permits the direct application of conventional statistical practices to sedimentary data. The phi scale has integers for the Wentworth class limits which increases as the grain size decreases. The conversion of the Wentworth grade scale to the phi scale is accomplished by the formula:

$$\phi = -\log_2 E$$

where "E" is the value of the grain diameter in millimeters. The phi scale and the equivalent Wentworth grade limits are given in Table 5.

The statistical values derived from the cumulative curves and used in comparing the sediments are the sorting coefficient, So; the log quartile deviation, $\log_{10}$So; the

Table 4.- Quartile and corresponding phi values

Sample	Md (mm)	Q_1 (mm)	Q_3 (mm)	Mdø	Q_1ø	Q_3ø
A_{17}	.122	.102	.128	3.0	3.0	3.3
A_{16}	.124	.108	.126	3.0	3.0	3.2
A_{15}	.124	.108	.127	3.0	3.0	3.2
A_{14}	.128	.116	.132	3.0	2.9	3.1
A_{13}	.124	.108	.129	3.0	3.0	3.2
A_{12}	.124	.105	.138	3.0	2.9	3.3
A_{11}	.132	.117	.145	2.9	2.8	3.1
A_{10}	.128	.113	.140	3.0	2.8	3.1
A_8	.085	.052	.104	3.6	3.3	4.3
A_7	.186	.144	.204	2.4	2.3	2.8
A_9	.132	.118	.149	2.9	2.7	3.1
A_6	.131	.113	.151	2.9	2.7	3.1
A_5	.123	.104	.140	3.0	2.8	3.3

"degree of sorting", DSo; the phi quartile deviation, QDø; and the phi skewness, Skqø. These values are listed in Table 6.

The sorting coefficient of a sediment is determined by the square root of the third quartile diameter divided by the first quartile diameter and is derived by the formula:

$$So = \sqrt{\frac{Q_3}{Q_1}}$$

Table 5.- Comparison of phi scale to Wentworth grades

Wentworth Grades (mm)	Phi Scale (Ø)
32	-5
16	-4
8	-3
4	-2
2	-1
1	0
1/2	+1
1/4	+2
1/8	+3
1/16	+4
1/32	+5
1/64	+6
1/128	+7
1/256	+8

Trask (1932, pp. 67-76) stated that if the value of So is less than 2.5 the sediment is well sorted; if it is about 3.0 the sediment is normally sorted; if it is greater than 4.5 the sediment is poorly sorted. The values of the So

Table 6.- Statistical data of the samples of the basal Caddell sand

Sample	So	$Log_{10}So$	DSo	QDØ	SkqØ
A_{17}	3.50	0.049	1.8	0.15	0.15
A_{16}	3.28	0.034	1.2	0.10	0.10
A_{15}	3.29	0.035	1.3	0.10	0.10
A_{14}	3.13	0.028	1.0	0.10	0.00
A_{13}	3.32	0.039	1.4	0.10	0.10
A_{12}	3.54	0.060	2.1	0.20	0.10
A_{11}	3.25	0.047	1.7	0.15	-0.05
A_{10}	3.31	0.046	1.6	0.15	0.05
A_{8}	6.20	0.151	5.4	0.50	0.20
A_{7}	3.13	0.076	2.7	0.25	0.15
A_{9}	3.26	0.051	1.8	0.20	0.00
A_{6}	3.44	0.063	2.3	0.20	0.00
A_{5}	3.59	0.065	2.3	0.25	0.05

increase geometrically rather than arithmetically; hence, the individual values cannot be directly compared.

Direct comparison can be made by converting the values of So into logs of So which form an arithmetic series. This conversion is accomplished by the formula:

$$Log_{10}So = \frac{(\log Q_3 - \log Q_1)}{2}$$

To compare the sands with one another, sample A_{14} was

selected as the unit sample with a log So value of 0.028. The "degree of sorting" of a sample is derived by dividing the log So value of that sample by the log So value of the unit sample. The degree of sorting of sample A_{12} is 2.1. Therefore, sample A_{12} has a spread of the grains that is 2.1 times the spread of the unit sample; or, the unit sample is 2.1 times as well sorted. (Table 6.)

The phi quartile deviation, QDØ, is the measure of one half the spread between the first and third quartile in terms of the Wentworth grades. The values of QDØ may be solved by the formula:

$$QD\emptyset = (Q_3\emptyset - Q_1\emptyset)/2$$

The difference between the quartiles indicates how many Wentworth grades lie between the first and third quartile. One half of this value is the quartile deviation; hence, the QDØ of the various samples may be readily compared.

The phi skewness, SkqØ, is the measure of departure of the frequency curve from being symmetrical. The value of SkqØ may be obtained by the formula:

$$Skq\emptyset = \frac{(Q_3\emptyset + Q_1\emptyset - 2\,(Md\emptyset)}{2}$$

The values of SkqØ range from positive to negative numbers. When the SkqØ is 0.0, the curve is symmetrical. If the

SkqØ is a positive number, the arithmetic mean of the quartiles lies to the right of the MdØ and the curve is skewed toward the positive value of Ø or skewed in the direction of the smaller Wentworth diameters. If the SkqØ is a negative number, the mean lies to the left of MdØ and the curve is skewed toward the negative value of Ø or skewed in the direction of the larger Wentworth diameter. (Table 6.)

Heavy Mineral Analyses

Procedure.- Bromoform was used as the heavy liquid to separate the light and heavy minerals. In all but two cases, 10 grams of each whole sample were used for the bromoform separation. In the case of sample A_{17}, 15 grams were used and only 9.25 grams of sample A_8. It was necessary to boil the latter sample in a 1:1 solution of HCL acid to remove the iron oxide cement present, as indicated in Table 7. Caution was taken that each sample was thoroughly disaggregated before proceeding with the bromoform separation. The evaporating dish method, prescribed by Professor Bullard, was followed in the separation. The light and heavy mineral fractions were allowed to dry in an electrical blower oven and weighed on a chemical balance to the nearest 0.0001 gram. The weights of the mineral fractions are given in Table 7.

Table 7.- Bromoform separations of heavy minerals

Sample	Weight of Sample (gm)	Heavy Mineral Weight (gm)	Heavy Mineral (%)
A_{17}	15.0	.0105	.07
A_{16}	10.0	.0245	.245
A_{15}	10.0	.0200	.2
A_{14}	10.0	.0251	.251
A_{13}	10.0	.0292	.292
A_{12}	10.0	.0113	.113
A_{11}	10.0	.0097	.097
A_{10}	10.0	.0104	.104
*A_8	9.25	.0006	.0065
A_7	10.0	.0005	.005
A_9	10.0	.0108	.108
A_6	10.0	.0105	.105
A_5	10.0	.0090	.09

*Treated with HCL for .75 gm. iron oxide before separation.

The heavy minerals of each sample obtained in the bromoform separation were split into small fractions with a microsplit and permanent mounts prepared in Canada balsam. The number of splits and the fraction of each sample used for the mounts are indicated in Table 8.

Table 8.- Amount of heavy mineral mounted

Sample	Splits (No.)	Portion Mounted (fraction)
A_{17}	3	1/8
A_{16}	3	1/8
A_{15}	2	1/4
A_{14}	4	1/16
A_{13}	4	1/16
A_{12}	3	1/8
A_{11}	2	1/4
A_{10}	3	1/8
A_8	(entire fraction)	
A_7	(entire fraction)	
A_9	3	1/8
A_6	3	1/8
A_5	2	1/4

Approximately 300 to 400 grains in random traverses were counted on each mount and the percentages calculated on the basis of 100 per cent. Mineral species were identified and counted by means of a petrographic microscope, employing a mechanical stage. The standard procedure for finding the optical properties and characteristics of minerals was used.

Heavy Mineral Descriptions

The heavy mineral content of the basal Caddell sand is practically 100 per cent of the more durable minerals which may have survived multiple cycles of erosion and deposition. The count and percentages of the mineral species for each sample are given in Tables 9 and 10 respectively.

Following is a brief description of the character of the heavy mineral species found in the basal Caddell sand:

Opaque Minerals: Magnetite and ilmenite are abundant in all samples. Magnetite is bluish-black and ilmenite is purplish-black in reflected light, both having a metallic luster. They occur in subangular to rounded grains. Some ilmenite shows partial alteration to leucoxene which also is prominent in a few samples. Leucoxene occurs as white to yellow-brown, well rounded grains, sometimes with an unaltered core of ilmenite. Limonite, prominent in several samples, is dark yellow-brown to brown and occurs in rounded granules. Hematite, present only in minor amounts, occurs in dark reddish to black grains with a submetallic luster.

Zircon is abundant in all of the samples with the exception of A_{17} where it occurs mostly as well worn eliptical to globular grains and short prisms. On the whole, the grains are short to moderately elongate worn euhedra.

Kyanite is rare to absent. The grains are somewhat rounded, frequently with carbonaceous inclusions and exhibit

Table 9.- Heavy mineral analyses of basal Caddell sand
(by number of grains)

Mineral	Samples						
	A_5	A_{10}	A_{11}	A_{13}	A_{15}	A_{16}	A_{17}
Magnetite	48	89	81	65	166	56	250
Ilmenite	77	105	52	93	23	84	25
Leucoxene	11	65	16	100	24	71	7
Hematite	18	15	14	4	4	5	5
Limonite	56	47	64	28	12	13	8
Zircon	77	53	57	101	115	91	6
Kyanite	4	5	5	2	4	3	
Tourmaline	17	9	6	8	4	10	5
Rutile	3	4	5	6	7	3	
Monzanite	3	5	10				4
Biotite	1	2	3	1	2	1	2
Muscovite	2						1
Garnet	1		2	2	4	1	
Anatase	2		4				
Staurolite	4	4	1	2	1		1
Enstatite	1	3	3	2		2	
Total	325	406	323	414	366	340	314

Table 10.- Heavy mineral analyses of basal Caddell sand (percentage by number of grains)

Mineral	Samples						
	A_5	A_{10}	A_{11}	A_{13}	A_{15}	A_{16}	A_{17}
Magnetite	14.8	21.9	25.1	15.7	45.3	16.5	79.7
Ilmenite	23.7	25.9	16.1	22.5	6.2	24.7	7.9
Leucoxene	3.3	16.0	4.9	24.2	6.5	20.9	2.2
Hematite	5.5	3.7	4.3	0.9	1.0	1.4	1.5
Limonite	17.2	11.6	19.8	6.7	3.2	3.8	2.5
Zircon	23.7	13.1	17.7	24.4	31.4	26.8	1.9
Kyanite	1.2	1.2	1.5		1.0	0.8	
Tourmaline	5.2	2.2	1.8	1.9	1.0	2.9	1.5
Rutile	0.9	0.9	1.5	1.4	1.9		
Monzanite	0.9	1.2	3.1				1.2
Biotite			0.9				0.6
Muscovite	0.6						
Garnet					1.0		
Anatase	0.6		1.2				
Staurolite	1.2	0.9					
Enstatite			0.9				
Others	1.3	1.4	1.2	2.3	1.5	2.2	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

yellow staining particularly along the traces of cross-cleavage.

Tourmaline is present in all the samples and varies from elongate prismatic grains having rounded terminations to well-rounded oval grains. Essentially, all the grains are pleochroic from colorless or pale yellow to some shade of violet, brown, or green.

Rutile, present in small amounts, occurs in elongate, rich red-brown prisms usually having rounded pyramidal ends.

Monzanite is present in only a few samples as highly rounded, greenish-yellow ellipsoids.

Biotite, represented by not more than three grains in any one total count, occurs in brown, irregularly rounded grains containing a few inclusions.

Muscovite, present only in A_5 and A_{17}, is colorless and occurs in thin, transparent flakes of low optical relief and a bluish-gray interference color.

Garnet is present only in very minor amounts in several of the samples. The garnet is a pale pink variety occurring in angular, irregular grains recognized by the well-developed conchoidal fracture.

Anatase grains, rectangular in outline and yellowish-blue in color, are sparsely represented in only two samples.

Staurolite occurs in golden-yellow to straw-yellow sub-angular fragments only as a trace in most of the samples.

Enstatite is uncommon, occurring as colorless, irregular fragments marked by high relief and low birefringence.

Glauconite Analyses and Content

The light mineral suites obtained in the bromoform separation were used for the glauconite analyses. Glauconite, moderately magnetic, is the only magnetic mineral present in the light suite. Thus, it was possible to separate it from the other minerals, consisting mostly of angular, subrounded to well rounded quartz grains with conchoidal fracture and some pitted surfaces. An electromagnetic separator, set at 100 volts, was used to make the separation.

The entire light suite was used in every case. A small fraction of a suite was placed on a stiff card on a stage and adjusted a short distance below the poles of the electromagnet. The distance of the stage below the poles and the spacing of the electromagnet poles were obtained after several experiments. The card with the light fraction was moved back and forth under the poles until no more glauconite grains collected at the poles. The card was removed, the electric current switched off, and the glauconite grains were permitted to fall onto a new card. This process was repeated until all the light mineral suite had been worked through. In order to insure a complete separation, the process was repeated a second

time on each suite.

The results of the glauconite separation, tabulated in Table 11, indicate the range of glauconite content from 0.15 per cent in Sample A_8 to 8.2 per cent in Sample A_7. The low content in A_8 can probably be attributed to the alteration of the glauconite to limonite caused by weathering. In the remaining samples, the glauconite content varied from 3 to 7.5 per cent.

The glauconite, essentially of the same character in all of the samples, occurs in semi-opaque, light olive, dirty olive-green, to dark grass-green, well rounded grains. The grains are mostly ovoid in shape and granular in structure although somewhat flattened, irregular spongy grains as well as well rounded, reticulated pellets with a polished surface are present in all of the samples. Few brown unaltered biotite grains and larger amounts of somewhat rounded, elongate accordion-like biotite grains with a lamellar structure and a powdery glauconite forming along the cleavage planes are also present in the samples.

Summary and Conclusions

The mechanical analyses of the basal Caddell sands indicate the mode to be 1/8 mm., and the grade size to range between 1/2 to 1/128 mm. (See fig. 8.) According to Went-

Table 11.- Electromagnetic separation of glauconite

Sample	*Weight of Sample (gm)	Glauconite Content (gm)	Glauconite Content (%)
A_{17}	15.0	.4887	3.25
A_{16}	10.0	.4350	4.35
A_{15}	10.0	.6802	6.802
A_{14}	10.0	.7535	7.535
A_{13}	10.0	.5155	5.155
A_{12}	10.0	.5801	5.801
A_{11}	10.0	.4508	4.508
A_{10}	10.0	.3045	3.045
A_8	9.25	.0140	0.15
A_7	10.0	.8255	8.255
A_9	10.0	.6274	6.274
A_6	10.0	.4408	4.408
A_5	10.0	.3955	3.955
Average	10.33	.5009	4.884

*Weight of original sample used in bromoform separation.

worth (1922, pp. 377-392), the sediment falls into the silty to fine sand classification.

The light mineral suites consist of subround to angular

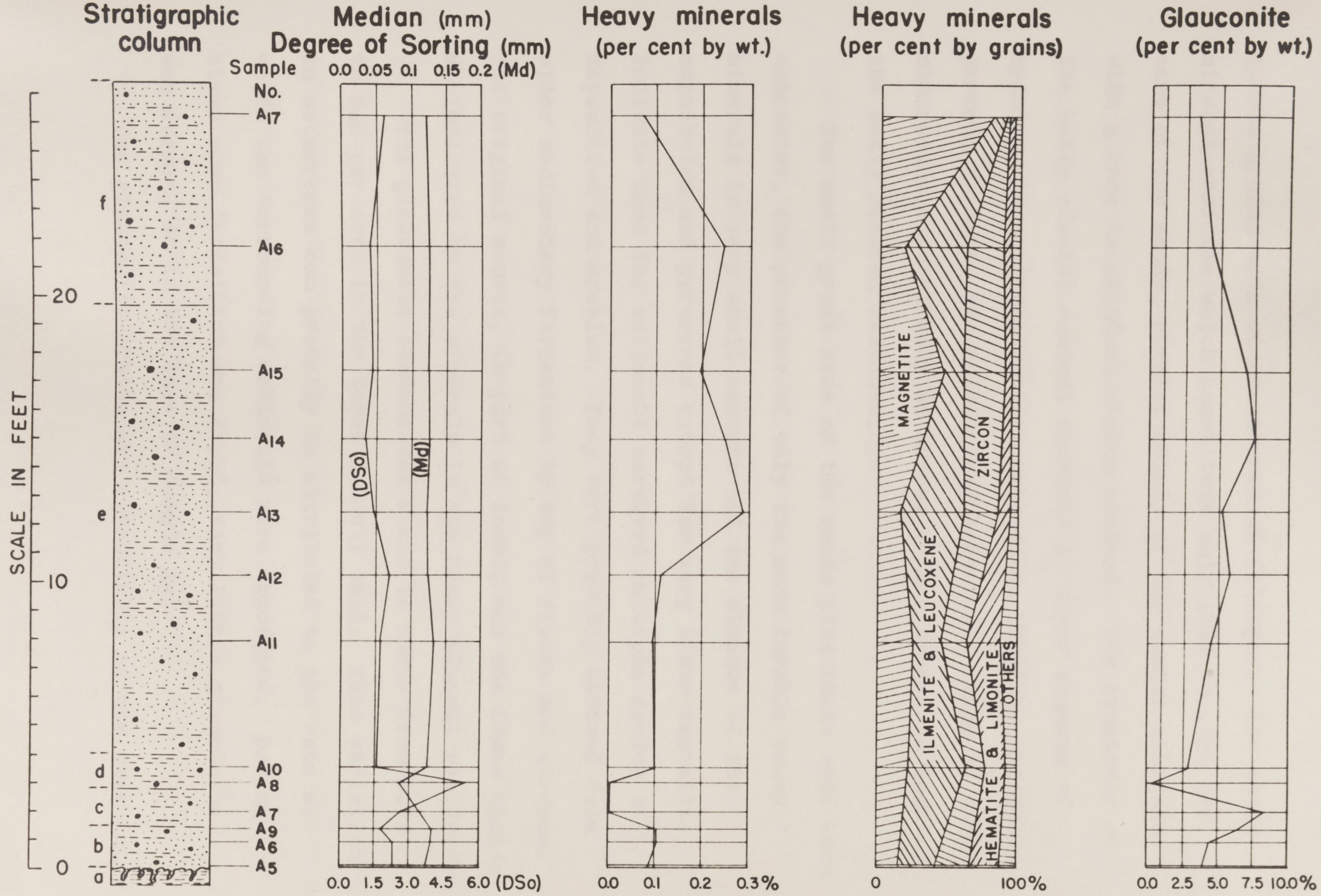

Figure 8. Results of the laboratory analyses of the basal sand of the Caddell formation

quartz grains with minor amounts of feldspar. The heavy mineral residues which constitute only .005 to .292 per cent of the sands, consist mainly of the opaque minerals with a rare to abundant zircon content. The remainder of the heavy mineral content consists of minor amounts of kyanite, tourmaline, rutile, monzanite, biotite, muscovite, garnet, anatase, staurolite, and enstatite. Many of these minerals are found only as traces or are absent in some of the heavy mineral residues.

The small grade size of the sands plus their well worn character, the presence of only the more durable heavy minerals in very small amounts and the absence of the amphiboles and pyroxenes except for very minor enstatite, indicate that the sediments survived multiple cycles of deposition and erosion. They were probably derived from older sedimentary formations by way of rivers and streams. The original source, in part at least, was the Llano region as indicated by the minerals in the heavy mineral residues.

The glauconite content was found to range from 0.15 to 8.2 per cent in the basal Caddell sand. This variation in occurrence can probably be attributed to the rate at which the surrounding sediments were deposited. During times when deposition was rapid, very little glauconite was formed, as in the case of Sample A8.

The glauconite grains are essentially of the same char-

acter in all the samples. No outstanding variations in the amounts of the different types of grains or differences in the character were detected in any one of the thirteen samples which ranged through 27.3 feet of section. All the grains are well rounded. Most of them are ovoid in shape and "sugary" or granular in structure. Each sample also contained flattened, irregular, spongy grains, well rounded, reticulated pellets as well as elongated, accordion-like biotite grains with a lamellar structure and a powdery glauconite forming along the cleavage planes. Few brown unaltered biotite grains are also present in the sample. The fact that they occur in the light mineral suites is probably due to their low iron content. The presence of brown unaltered biotite, green glauconite grains and the transition between the two in the sands deposited in an environment overlying the unconformity seems as very good evidence that the glauconite is altered biotite as concluded by Galliher (1935, pp. 1569-1601) and other authorities. In his investigation off the coast of California, Galliher found all stages from fresh and undecomposed biotite through all intermediate forms to true glauconite. He also discovered that the deposition is slow during the formation of the glauconite and that the glauconite forms best in waters 50 fathoms deep. A German scientist found that glauconite formation requires a temperature of about 5-15° C. A study of glauconite

made by Gruner (1935, pp. 699-714) shows that the glauconite is a mica in structure. Schneider (1927, pp. 289-310) expressed the composition of glauconite by the formula (K, Na) (Fe, Mg) (Fe, Al)$_3$Si$_6$O$_{13}$ · 3H$_2$O.

The poorly to massive bedded nonmarine Yegua clays with lignitized material were deposited in coastal swamps. During this time, the upper Yegua bordering the coast was subsiding slowly and accumulating terrestial deposits. As the Caddell sea encroached upon the continental Yegua strata, the upper surface was left eroded and wavy. Deposition of the poorly to cross-bedded slightly glauconitic basal Caddell sands took place at a slow rate during which time the glauconite formed. Oscillation and retreats of the shallow Caddell sea made it possible for the deposition of the thin interbedded clays. Burrows made by burrowing crustaceans at the bottom of the very shallow Caddell sea as indicated by the cross bedding of the sand, extend into the Yegua clays and are filled with the Caddell glauconite sands. The contact between the two formations is sharp and the disconformity possibly represents a large interval of time during which the deposition proceeded at a very slow rate.

Measured Sections

Explanation

The stratigraphic section of the Jackson group, the Catahoula, and the lower Oakville formation in the Muldoon area consists of approximately 900 feet of sediments. During the field work, 43 separate surface sections were measured along gullies and creeks. Thicknesses were measured with a Locke hand and a 6-foot steel tape or by right angle computations. Of the 43 separate sections, only 27 were correlated and tied in stratigraphically with each other by lithology or by elevations and combined in the form of a composite section (Plate II). The locations and descriptions of the 27 measured sections are given in the following pages. The locations of the sections are also shown on the geologic map (Plate I).

Section 28. Yegua-Caddell section in east bank of road cut on descent, 1.72 miles northwest from the Muldoon post office along Muldoon-Cistern county road and 0.6 miles north along county road; near northwest corner of E. Cherry 182-acre tract, near center of M. Muldoon survey No. 6.

Description	Thickness Feet
Caddell:	
h. Soft, blackish-gray sandy top soil	1.3
g. Weathered light reddish-gray, limonite-stained clayey sand with clay partings	2.4
f. Firm, locally partly indurated due to limonite cementing, gray when fresh, light gray on weathered surface, poorly bedded, glauconitic clayey sand interbedded with firm to friable, gray to chocolate-brown, poorly bedded, slightly carbonaceous clay in thin layers and irregularly disseminated fragments up to 0.5 inch in diameter	7.6
e. Loose to slightly firm, light gray to gray with greenish tint, even- to cross-bedded, glauconitic, fine-grained sands up to 1.5 feet thick somewhat limonite-stained along bedding planes, interbedded with firm, gray, lenticularly bedded, conchoidally fracturing, bentonitic clays up to 0.5 inch in thickness, occupying zones up to 6 inches in the sand	15.7
d. Firm, sticky when wet, grayish-brown to chocolate-brown, conchoidally fracturing, thinly bedded, slightly bentonitic, silty clay with thin layers of loose, light gray, lenticularly bedded sand in basal part	1.2

Section 28. (Continued)

Description	Thickness Feet
c. Soft to loose, light gray to light greenish-gray, thinly to cross bedded, glauconitic, fine-grained sands with few firm, grayish-brown, bentonitic, carbonaceous clay layers up to 0.5 inch in thickness; sands somewhat limonite stained along bedding planes	1.0 to 1.3
b. Firm, sticky, chocolate-brown to dark chocolate-brown when fresh, brownish-gray on weathered surface, massive to thinly and lenticularly bedded, silty, bentonitic, carbonaceous clay interbedded with loose, light gray, poorly bedded, glauconitic fine-grained sands up to 1.5 inch thick stained along bedding planes adjacent to clay; resting on undulating surface of (a)	1.5
Disconformity	
Yegua:	
a. Firm, chocolate-brown to grayish-brown, massive to poorly bedded, conchoidally fracturing, silty, bentonitic clay with abundant lignitized plant fragments; in upper 4 to 8 inches with vertical to horizontal pipe-like burrows up to 1 inch in diameter filled with the overlying glauconitic sand; bottom not exposed	3.0
Total	34.0

Section 22. Caddell section in gully in the W. Cherry land, starting in gully mouth and continuing 260 yards up stream in abandoned field, 420 yards due north of farm house, 4.0 miles southwest of Muldoon post office, or 2.5 miles S. 75° W. of Muldoon, airline distance; northwest part of W. Cherry 954-acre tract, northwest part of F. A. Bettinger survey.

Description	Thickness Feet
Lower Caddell:	
d. Light brownish-gray sandy soil	2.5
c. c_2. Loose to soft, dark greenish-gray to light ashy-gray, cross-bedded, glauconitic sands with some light gray to gray, poorly bedded clay and several calcareous sandstone layers up to 0.5 foot thick with aragonite concretions, forming small ledges in gully; poorly exposed	11.4
c_1. Loose to soft, dark gray to dark greenish-gray, thinly bedded but not laminated, muscovitic, glauconitic, fine-grained sands up to 1 foot thick locally limonite-stained, interbedded with firm, gray, lenticularly bedded silty clays in thin layers, pebbles and partings locally intermixed with brownish carbonaceous material and argillaceous silts in layers up to 0.3 inch in thickness; presence of 3 to 4-inch layers of hard, gray, calcareous sandstone with radial aragonite concretions 1 foot above base and at various levels in the sand	10.8
b. Firm, dark gray, massive bedded, bentonitic clay	11.5
a. Hard and indurated, dark gray, massive to cross-	

Section 22. (Continued)

Description	Thickness Feet
bedded, glauconitic calcareous sandstone with radial aragonite concretions up to 0.5 foot in diameter; bottom not exposed	6.0
Total	42.2

Section 38. Caddell section in north bank of abandoned clay pit in Chandler Branch tributary, 2.8 miles northeast of Muldoon post office along the Muldoon-West Point road to road-T 350 yards northwest of Buckners Creek bridge, 0.8 miles west-northwest from cattleguard entrance along private clay pit road, 350 yards north to clay pit through woods along abandoned road not accessible to car; north part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5.

Description	Thickness Feet
Caddell:	
d. Light brownish-gray sandy soil	0.9
c. Friable, light brown clayey sandy soil	2.0
b. Firm, light to dark gray, locally limonite-stained to rusty-yellow color, lenticularly to poorly bedded, muscovitic, tuffaceous, argillaceous, silty sand with small, irregularly disseminated, firm, dark gray, bentonitic clay pebbles and partings, and absence of fossil mollusks	3.3
a. a_2. Friable, gray, poorly bedded, tuffaceous, silty clay, the lower part becoming dark gray, conchoidally breaking, very clayey and bentonitic	2.3
a_1. Friable and waxy, light gray, poorly to unbedded, bentonitic clay, slightly carbonaceous in parts; bottom not exposed	5.0
Total	13.5

Section 36. Caddell section in banks of Chandler Branch tributary, 2.8 miles northeast of Muldoon post office along Muldoon-West Point road to road-T 350 yards northwest of Buckners Creek bridge, 1.2 miles west-northwest from cattleguard entrance along private clay pit to site of abandoned house and 280 yards due north across woods to creek, or 2.4 miles due north of Muldoon, airline distance; northwest part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5.

Description	Thickness Feet
Caddell:	
f. Light tan-gray, clayey sand soil	0.8
e. Firm, light brownish-gray, weathered clays and silts	5.4
d. Firm to friable, light gray to gray when fresh, light gray on weathered surface, slight brownish where carbonaceous, lenticularly bedded, bentonitic, silty clays interbedded with light tan to light gray, lenticularly to poorly bedded, clayey silt up to 3 inches in thickness; presence of secondary white calcareous material in small seams and pockets. Downstream and northeast along the strike, this becomes a firm to friable, poorly to lenticularly bedded, light to dark gray, argillaceous, muscovitic sandy silt with firm, hard when dry, slightly silty, bentonitic clay in layers up to 1 inch thick	3.3 to 6.0
c. Loose and soft, tan to light gray when fresh, rusty yellowish-gray on weathered surface, poorly bedded, fine-grained sands; downstream becoming a firm, light to dark gray, lenticularly to poorly bedded, muscovitic, tuffaceous, argillaceous, silty	

Section 36. (Continued)

Description	Thickness Feet
sand stained to rusty reddish color, with small irregularly disseminated firm, dark gray, bentonitic clay pebbles and partings. Fossil mollusks present throughout, but more abundant in certain zones and small lense-like pockets up to 4 by 1.5 inches	2.2 to 3.3
b. Firm to friable, waxy when wet, light to dark gray, light brownish-gray in carbonaceous portions, light gray where more silty, poorly to lenticularly bedded, bentonitic, tuffaceous, silty clays interbedded with firm to soft, light gray to tan-gray, limonite-stained locally, lenticularly to thinly bedded but not laminated, bentonitic, clayey silts up to 1 inch in thickness	6.8
a. Firm to soft, grayish-tan, poorly bedded, muscovitic, very silty sands with firm, chocolate-brown to brownish-gray, bentonitic, carbonaceous, silty clay partings, pebbles, lenses and layers up to 0.5 inch in thickness; bottom not exposed	3.0
Total	25.3

Section 31. Caddell section in gully tributary of Live Oak Creek, 3.17 miles north-northwest from Muldoon post office along Muldoon-Cistern county road to Parkerville Store, 1.53 miles south along road, 245 yards due west from road in H. Lueders land, starting 50 yards up stream and ending in head of gully on the edge of an abandoned field; 3.37 miles S. 65° W. from Muldoon, airline distance; north part of H. Lueders 252-acre tract, F. A. Bettinger survey.

Description	Thickness Feet
Caddell:	
f. Light reddish-gray clayey sand; in the upper 0.5 foot a light brown sandy soil	2.5
e. Loose to soft, tan to tanish-gray, lenticularly bedded, fine-grained sands interbedded with firm, gray when fresh, light gray on weathered surface, bentonitic, silty clay in layers up to 1 foot thick, with some clayey silt; in lower half considerably obscured by alluvium, the sand becomes firm, dark gray, lenticularly bedded, locally limonite-stained and interbedded with bentonitic, silty clay layers up to 4 inches thick, thin clay partings and pebbles up to 1 inch in diameter disseminated throughout. A 3-inch layer of calcareous sandstone with aragonite concretions is present 2 feet from top of bed	9.5
d. Firm and hard, dark gray, stained black on surface, poorly to unbedded, calcareous, medium-grained sandstone with flat aragonite concretions up to 1.7 feet in length	0.5 to 1.0

Section 31. (Continued)

Description	Thickness Feet
c. Soft, light gray, lenticularly to poorly bedded, fine-grained sands with friable to waxy and sticky when wet, light gray to dark gray, locally slightly carbonaceous, bentonitic clay partings and thin layers up to 0.5 inch in thickness; limonite-stained locally	5.9
b. Same as (d)	1.1
a. Same as (c); bottom not exposed	5.0
Total	25.0

Section 30. Caddell section in gully, starting at head in abandoned field and continuing 140 yards downstream into wooded area, 280 yards northwest of the H. Lueders house, 4.0 miles southwest of Muldoon post office; southwest part of H. Lueders 252-acre tract, southwest part of F. A. Bettinger survey.

Description	Thickness Feet
Caddell:	
c. Firm, light brown, clayey sandy soil	1.9
b. Firm to soft, light gray to tan-gray, poorly to lenticularly and locally thinly bedded but not laminated, slightly bentonitic, muscovitic, clayey sand interbedded with firm to friable, light chocolate-gray to chocolate-brown when fresh, light gray on weathered surface, lenticularly bedded, bentonitic, carbonaceous, silty clays in partings and layers up to 3 inches in thickness with some clayey silts; thin yellow-red limonitic laminations weathering out and few white, irregular lime nodules up to 1 inch in diameter scattered on surface ...	11.0
a. Similar to (b) but more sandy and thinly bedded; bottom not exposed	1.5
Total	14.4

Section 37. Caddell section in south bank of Chandler Branch, 2.8 miles northeast of Muldoon post office along the Muldoon-West Point road to road-T 350 yards northwest of Buckners Creek bridge, 0.6 miles southwest from cattleguard entrance along private clay pit road, 100 yards northeast through woods to creek; or 2.3 miles N. 15° E. of Muldoon, airline distance; north part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5.

Description	Thickness Feet
Caddell:	
e. Light gray, clayey sand soil	0.5
d. Weathered sand and shale forming a light brownish-gray clayey sandy soil	1.0
c. Loose and soft, light gray to tan-gray, lenticularly and thinly bedded but not laminated, muscovitic fine-grained sands up to 8 inches thick interbedded with firm, light chocolate-brown when fresh, light gray on weathered surface, lenticularly bedded, irregularly breaking, slightly carbonaceous, bentonitic, silty, shale in layers up to 1 inch thick; presence of a white, tuffaceous, clayey silt up to one-eighth of an inch thick on some bedding planes	8.9
b. Loose and soft, light gray when fresh, gray on weathered surface, even-bedded, fine-grained sands with few firm to friable, chocolate-brown, bentonitic, silty shale partings and layers up to 0.5 inch thick in basal 2 feet; sands lenticularly bedded in basal 1.5 feet, resting on wavy, uneven surface of (a)	4.9

Section 37. (Continued)

Description	Thickness Feet
a. Firm, chocolate-brown when fresh, light brownish on weathered surface, light chocolate-gray where very silty, thinly and lenticularly bedded, bentonitic, carbonaceous, slightly silty shales with lignitized plant fragments and gypsum crystals and rosettes weathered out on surface, interbedded with a friable, light tan, lenticularly and thinly bedded but not laminated, bentonitic, argillaceous silt up to 3 inches thick; presence near the base of a firm, grayish-tan, 2.5 by 0.6 feet, calcareous, fine-grained sandstone lense adjacent to a calcareous sandstone septarium 1.3 feet in diameter with the shrinkage cracks filled by gypsum and the shale arching over it; bottom not exposed	7.3
Total	22.6

Caddell:

d. Light gray sandy soil	2.0
c. Firm to waxy, brownish-gray, weathered silty clay	10.2
b. Loose, tan-gray when fresh, light gray on weathered surface, poorly to lenticularly bedded slightly clayey in parts, muscovitic fine-grained sand ...	3.0
a. Firm, light to dark chocolate-brown when fresh, light chocolate-gray on weathered surface, poorly bedded, bentonitic, carbonaceous, slightly silty shale with small gypsum rosettes and plates, with very few one-fourth of an inch pelecepod casts; bottom not exposed	12.3
Total	27.5

Section 34. Caddell section in north bank of Buckners Creek bend, 2.8 miles northeast of Muldoon post office along Muldoon-West Point road to road-T 350 yards northwest of Buckners Creek bridge, 0.5 mile southwest from cattleguard entrance along private clay pit road and wagon trail across first abandoned field south of Chandler Branch to small clearing, 70 yards south-southeast over cow trail to creek; or 2 miles N. 20° E. of Muldoon, airline distance; north-central part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5

Description	Thickness Feet
Caddell:	
d. Light gray sandy soil	2.0
c. Firm to waxy, brownish-gray, weathered silty clay	10.2
b. Loose, tan-gray when fresh, light gray on weathered surface, poorly to lenticularly bedded slightly clayey in parts, muscovitic fine-grained sand ...	3.0
a. Firm, light to dark chocolate-brown when fresh, light chocolate-gray on weathered surface, poorly bedded, bentonitic, carbonaceous, silty shale with small gypsum rosettes and plates, with very few one-fourth of an inch pelecopod casts; bottom not exposed	12.3
Total	27.5

Section 32. Caddell section in banks of small creek tributary of Pin Oak Creek, 35 yards south of abandoned county road in the Foster land, starting 175 yards west of wire gate near new county road bend, continuing 100 yards downstream; 0.7 mile west from the Muldoon post office along Muldoon-Cistern county road; southeast part of Mrs. E. Foster 217-acre tract, M. Muldoon survey No. 6.

Description	Thickness Feet
Caddell:	
f. Soft, brownish-gray sandy soil	1.1
e. Firm, light brown, weathered clayey sand	2.5
d. Firm, deep rusty reddish-yellow to rusty brown, lenticularly bedded, limonite-stained, somewhat clayey fine-grained sands	1.3
c. Firm to crumbly, waxy and sticky when wet, light chocolate-brown when fresh, light brown on weathered surface, poorly to lenticularly bedded, bentonitic, carbonaceous, silty clay	5.0
b. Firm to loose and soft, light tan-gray, locally rusty yellow-streaked, lenticularly bedded, slightly muscovitic fine-grained sands with a firm, whitish-gray, tuffaceous, clayey silt up to one-fourth of an inch thick along some bedding planes, with fossil worm burrows knotty on outside surfaces and filled with a light gray, unstained sand; locally becoming a firm, light gray, clayey sand .....8.0 to	9.0
a. Firm to friable, chocolate-brown when fresh, brownish-gray on weathered surface, thinly to lenticularly bedded, conchoidally fracturing, slightly silty, bentonitic, shale interbedded with friable, light	

Section 32. (Continued)

Description	Thickness Feet
brown to gray when fresh, light gray on weathered surface, thinly to lenticularly bedded, muscovitic, carbonaceous, argillaceous silts in lenses and layers up to 3 inches in thickness; also with brownish, very carbonaceous shale up to 0.5 inch thick between some bedding planes; bottom not exposed	9.3
Total	28.2

Section 33. Caddell-Middle Wellborn section in banks of deep gully, northeastern most of four, starting 50 yards west of rocky ridge and 385 yards north of the J. Boehnke house; 1.2 miles southwest from the Muldoon post office along Farm road No. 154; northeast part of Theo. Hinze 30-acre tract, Wm. M. Evans survey.

Description	Thickness Feet
Middle Wellborn equivalent:	
g. Light brown sandy top soil	1.3
f. Firm to loose, light brown-gray when fresh, rusty-brown streaked on weathered surface, lenticularly and thinly bedded, slightly carbonaceous, argillaceous fine-grained sand	2.3
Caddell:	
e. Firm to soft, light brownish-gray when fresh, light rusty brownish-gray on weathered surface, lenticularly and thinly bedded, bentonitic, argillaceous, slightly muscovitic, carbonaceous silts with lignite partings up to 0.5 inch in thickness, interbedded with firm, chocolate-brown, thinly bedded but not laminated, conchoidally fracturing, bentonitic, carbonaceous, shales up to 4 inches thick; reddish limonite-stained locally	8.8
d. Firm, chocolate-brown in the more argillaceous layers, brown-gray in the more silty layers, thinly bedded but not laminated, conchoidally fracturing shale and rusty yellow-stained on surface, slightly muscovitic, clayey silts interbedded with brown lignite partings up to 0.5 inch in thickness, and thin gypsum	

Section 33. (Continued)

Description	Thickness Feet
laminations weathering out; down stream becoming a firm, chocolate-brown, poorly bedded, conchoidally breaking, bentonitic, carbonaceous shale with little silt present	12.3
c. Firm to friable, light chocolate-brown when fresh, light brownish-gray on weathered surface, poorly to lenticular and thin-bedded, bentonitic, carbonaceous, muscovitic, very clayey silts with light chocolate-brown shale partings, some glauconitic sands, lignitized plant fragments and thin gypsum rosettes on some bedding planes; limonite-stained locally	10.3
b. Firm to soft, light tan-gray when fresh, light gray on weathered surface, thin-bedded but not laminated, locally slightly carbonaceous, muscovitic fine-grained sands with lignite partings up to one-fourth of an inch in thickness	5.0
a. Loose and soft, light tan-gray when fresh, light gray on weathered surface, poorly bedded, fine-grained sand, firm in upper foot, with firm, light chocolate-brown, carbonaceous, bentonitic, silty shale pebbles up to 1.5 inches in thickness; bottom not exposed	4.8
Total	44.8

Section 29. Caddell-Wellborn section, old road alongside and cut on west side of Muldoon-West Point county road, on ascent from and 500 to 600 feet southeast of iron bridge over Buckners Creek, 2.4 miles northeast of Muldoon, Fayette Co.

Description	Thickness Feet
Carlos sandstone:	
e. Hard, whitish gray, medium-bedded, long-lenticular, argillaceous, slightly glauconitic sandstone with a tendency to conchoidal fracture particularly on flat top surfaces of the ledges, with well developed parallel joints, with blackened outside surfaces, but without fossil mollusks. This sandstone forms an extensive dip slope surface and is quarried in countless small pits	8.6
Middle Wellborn equivalent:	
d. Partly hardened in small lenses, but as a whole only firm to loose, very light brownish-gray when fresh, rusty yellow-brown streaked on weathered surface, lenticularly and thinly bedded, slightly carbonaceous, argillaceous fine-grained sands with some one fourth of an inch thick, very soft, black-brown, sandy lignite partings	14.9
c. Short lenses of hard, grayish-chocolate-brown, poorly to thinly bedded, conchoidally fracturing, carbonaceous clay with silicified wood, the largest of which is 0.5 by 1.4 feet in diameter and at least 1.2 feet long, all with shipworm boreholes. Largest lense is 6.3 feet wide and up to 1.2 feet thick	up to 1.8

Section 29 (Continued)

Description	Thickness Feet
Caddell:	
b. Firm to soft, light brownish-gray when fresh, light rusty brown-gray on weathered surface, lenticularly and thinly bedded, bentonitic, argillaceous, slightly muscovitic, carbonaceous silts with some flat, thin gypsum rosettes, lower 1.8 feet slightly harder	8.7
a. Firm, chocolate-brown in the more argillaceous layers, thinly bedded but not laminated, conchoidally fracturing, bentonitic, carbonaceous shale and very argillaceous, slightly muscovitic silts interbedded with small lignitized plant fragments on some bedding planes; bottom not exposed	5.7-
Total	37.9

Section 43. Wellborn section in small abandoned sandstone quarry 50 yards east of railroad bridge crossing Buckners Creek, 2.5 miles northeast of Muldoon and 490 yards due east of Section 29, east part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5.

Description	Thickness Feet
Carlos sandstone:	
b. Hard, whitish-gray, medium- to massive-bedded, slightly glauconitic sandstone with well developed joints and blackened exposed surfaces; forms extensive dip slope surface and is quarried in countless small pits	10.4
Middle Wellborn equivalent:	
a. Hardened in small lenses up to 0.7 foot thick, but as a whole only firm to loose, very light brownish-gray when fresh, rusty yellow-brown streaked on weathered surfaces, lenticularly and thinly bedded, slightly carbonaceous, argillaceous fine-grained sands with some small, soft, black-brown, sandy lignite partings; bottom not exposed	8.7
Total	19.1

Section 14. Manning section in gully tributary of Buckners Creek, starting 525 yards south of railroad bridge over Buckners Creek and 140 yards east of northeast corner of abandoned field, continuing 160 yards downstream in the Earl McKaughan wooded land; 1.5 miles northeast from the Muldoon post office along Muldoon-West Point road, 0.2 mile east from Wrightman Crossing along county road, and 0.7 mile north-northeast along private road through abandoned field to edge of woods; east part of Earl McKaughan 3500-acre tract, M. Muldoon survey No. 5.

Description	Thickness Feet
Manning:	
h. Light tan, unbedded sandy soil	1.0 to 1.5
g. Friable, gray to tan-gray, thin- to lenticular-bedded, interbedded tuffaceous, clayey sand and sandy clay with a hard indurated light gray, massive sandstone 1 to 2 inches thick near the base with ripple marks on upper surface; some brown to gray clay pebbles present in the sandy clay	8.3
f. Hard, indurated, light gray, poorly bedded, sub-angular to rounded, tuffaceous, medium-grained sandstone	1.3
e. Firm, gray, lenticular- to cross-bedded, partially cemented, tuffaceous sands interbedded with some light gray sandy clay; locally with fossil worm burrows	4.0
d. Same as (f)	1.3

Section 14. (Continued)

Description	Thickness Feet
c. Firm, gummy and sticky when wet, dark gray to gray, slightly bentonitic clay with a soft, light gray clayey sand in layers up to three-fourths of an inch in thickness and a hard, indurated, light gray sandstone in layers up to 0.5 inch in thickness near top of bed; limonite-stained	8.7
b. Hard, gray, massive sandstone with few leaf impressions and locally with ripple marks; forms small, resistant ledge	0.3 to 0.5
a. Friable, chocolate-brown, poorly bedded, sandy shale; bottom not exposed	4.0
Total	29.6

Section 13. Manning section in banks of small tributary of Pin Oak Creek, starting in central part of London Kelly land at wagon crossing 175 yards west of house and continuing north across county road to mouth of tributary, ending 63 yards up stream in Pin Oak Creek or 35 yards east of west boundary of Jesse Bartlett survey; 2.5 miles northeast of Muldoon post office or 1.0 mile east of Wrightman Crossing along county road; central and north part of London Kelly 85-acre tract, Jesse Bartlett survey.

Description	Thickness Feet
Manning:	
c. Light tan-gray sandy soil grading down into a friable, brownish-gray, unbedded clayey sand	2.0
b. Soft, light chocolate-brown to light gray on fresh exposure, dark gray on smooth weathered creek banks, poorly to lenticularly bedded, tuffaceous, clayey sand with abundant small brown clay pebbles of various sizes disseminated locally throughout, with abundant worm burrows in parts filled with chocolate-brown clay, and with limonite staining, locally along bedding planes ..	6.7
a. Firm, light to dark chocolate-brown, thin- and even- to poor-bedded sandy shale, with carbonaceous plant fragments, locally with disseminated sand and silt throughout or between bedding planes; bottom not exposed	20.9
Total	29.6

Section 12. Manning section in banks of small creek, starting in head of gully 70 yards southeast of county road in W. Jurika land and continuing northwest across road into Chas. Wrightman land, 2.95 miles northeast from the Muldoon post office or 1.45 miles east of Wrightman Crossing along county road; northeast part of W. Jurika 40-acre tract, southwest part of Chas. Wrightman 80-acre tract, Jesse Bartlett survey.

Description	Thickness Feet
Manning:	
o. Light tan-gray sandy soil	2.0
n. Soft to indurated, dark gray to grayish-tan, massive- to cross-bedded tuffaceous sand and sandstone; in adjacent creek to the east, becoming clayey in upper 8 feet with firm, grayish-cream, flat, oblong clay pebbles and boulders up to 1.5 feet in diameter encased in a limonite-cemented crust weathering out on exposed surfaces	10.0
m. Soft, grayish-tan, massive-bedded, tuffaceous, clayey sand with small light brown to gray clay pebbles and partings disseminated throughout; intermixed with friable, brownish-gray to creamy-white, slightly bentonitic clays in upper 0.5 to 2 feet; abundant limonite laminations and concentric concretions weathered out on exposed surface	9.1
l. Firm, indurated, grayish-white, tuffaceous, fine-grained sandstone traversed by fossil worm burrows up to three-fourths of an inch in diameter	0.8
k. Firm, gray on fresh exposure, light gray on	

Section 12. (Continued)

Description	Thickness Feet
weathered surface, waxy, irregular breaking, slightly bentonitic clay limonite-stained on exposed surfaces; grading into (j)	2.0
j. Soft to friable, light chocolate-brownish-gray, sandy clay with small, light brown, clay pebbles disseminated throughout in lower 1 to 2 feet; grading into (i)	6.8
i. Firm, dark gray on fresh exposure, light gray on weathered surface, poorly bedded, slightly bentonitic clays with limonite-stained silt inclusions	6.0
h. Firm, light chocolate-colored, tuffaceous, clayey sand with brown clay partings up to 1.5 inches in length; locally limonite-stained	0.6
g. Soft, chocolate-brown to black, carbonaceous to lignitic shale	1.0
f. Firm, brown, poorly bedded, slightly bentonitic clay with disseminated clayey sand and silt; grading into (e)	0.8
e. e_3. Firm to friable, light brown, poorly bedded clayey sand becoming grayish and thin- to lenticular-bedded in lower part	3.7
e_2. Soft, light tan, lenticular-bedded, tuffaceous, fine-grained sand with oscillatory wave basins 1.3 feet in depth and 3 feet in length	1.7
e_1. Friable, light tan, thin-bedded sandy clay ..	1.5
d. Friable, light tan, massive, limonite-stained, tuffaceous, clayey sand; becoming a sandy clay in upper part	1.5
c. Firm, light gray, poorly bedded, slightly bentonitic clay with a soft, light brown, limonite-stained, tuffaceous, clayey sand disseminated throughout, filling the fossil worm burrows present	1.0

Section 12. (Continued)

Description	Thickness Feet
b. Soft, grayish-tan, massive, tuffaceous sand with friable, creamy-gray clay partings and irregular fragments	3.0
a. Firm, light chocolate-brown, poorly bedded, limonite-stained silty clay with dark brown clay pebbles and carbonaceous plant fragments and impressions; bottom not exposed	4.0
Total	55.5

Section 41. Manning section in shallow gully, starting at mouth and continuing 70 yards southeast up west slope of low knoll; 210 yards north of Section 40; southwest part of Chas. Wrightman 650-acre tract, Wm. Higgens survey.

Description	Thickness Feet
Manning:	
e. Light tan-gray sandy soil	1.0
d. Loose to indurated due to limonite, light rusty-gray to yellowish-red where indurated, cross- to lenticular-bedded, round to sub-round, tuffaceous, medium-grained sand with a friable, light gray, bentonitic, silty clay in lenses up to 2 inches in thickness	2.5
c. Friable, light chocolate-brown to light brownish-gray on fresh exposure, light gray on weathered surfaces, poorly-bedded silty, bentonitic, clay with lignitized plant fragments and limonite-stained in parts, interbedded with soft, light gray, clayey, fine-grained sands up to 8 inches in thickness, limonite stained locally; presence of remnants of a 0.6-foot layer of friable to firm, whitish-gray, unbedded, tuffaceous, clayey silt approximately 4.3 feet above the base	12.2
b. Soft, light gray, chocolate-brown where carbonaceous, lenticular-bedded, clayey sand with thin laminations of gypsum along certain bedding planes, limonite-stained to yellowish color on weathered surface, becoming more carbonaceous in upper part, interbedded with friable, chocolate-brown to dark gray, silty, lignitic, bentonitic shale becoming more abundant in basal 2 feet	5.3

Section 41. (Continued)

Description	Thickness Feet
a. Friable, sticky when wet, light chocolate-brown, brownish-gray where more silty, poorly bedded, slightly bentonitic, silty, lignitic shale with lignitized plant fragments; bottom not exposed ..	1.0
Total	22.0

Section 40. Manning section, banks of small gully in post oak-black jack oak woods in the Chas. Wrightman land, 1.65 miles southeast from the Muldoon post office along the Muldoon-La Grange county road, 930 yards north of road, and 190 yards north of Section 39; or .93 miles S. 40° E. from Muldoon, airline distance; southwest part of Chas. Wrightman 650-acre tract, Wm. Higgens survey.

Description	Thickness Feet
Manning:	
e. Light tan-gray sandy soil	1.0
d. Soft to firm, gray, lenticular-bedded tuffaceous clayey sand	2.0
c. Friable, dark gray on fresh exposure, light gray on weathered surface, poorly bedded, conchoidally breaking, slightly bentonitic, silty clay	1.5
b. Loose to firm, light gray to dark gray on fresh exposure, gray on weathered surface, lenticular- and cross-bedded, tuffaceous, medium-grained sand with a friable, gray, bentonitic, silty clay in lenses up to 1.5 inches in thickness; presence of a whitish-gray, tuffaceous silt along certain bedding planes in portions	5.3
a. Friable, light gray to chocolate-gray on fresh exposure, light gray on weathered surface, light gray where more sandy, poorly bedded, bentonitic, sandy clay, carbonaceous in parts and limonite-stained locally; bottom not exposed	2.7
Total	12.5

Section 39. Manning section in banks of winding creek, starting in head of gully immediately north of road and continuing 450 yards northeast through black jack-post oak woods on the edge of a cultivated field in the Chas. Wrightman land, 1.65 miles southeast from the Muldoon post office along the Muldoon-La Grange county road; south-central part of Chas. Wrightman 650-acre tract, Wm. Higgens survey.

Description	Thickness Feet
Manning:	
p. Friable, grayish-brown clayey sand soil	1.3
o. Firm, grayish-black clayey subsoil	1.0
n. Firm to friable, light creamy-gray to cream-colored on fresh exposure, light gray on weathered surface, poorly to lenticularly bedded, slightly bentonitic, silty clay; grading into (m)	9.0
m. Friable, light chocolate- to brownish-gray, lenticular-bedded, carbonaceous, silty clay; grading into (l)	1.3
l. Friable, gray on fresh exposure, light gray on weathered surface, lenticular- to thin-bedded, slightly bentonitic, clayey silt; carbonaceous along certain bedding planes	3.2
k. Friable, gray on fresh exposure, light gray on weathered surface, poorly bedded, slightly bentonitic, silty clay	5.5
j. j_3. Firm, light chocolate-gray on fresh exposure, light gray on weathered surface, poorly- to lenti-	

Section 39. (Continued)

	Description	Thickness Feet
	cular-bedded, slightly carbonaceous, tuffaceous, clayey silts resistant to weathering, forming ledge at small waterfall; grading into (j_2)	2.5
	j_2. Firm to friable, light chocolate-gray, tuffaceous, clayey silt with firm, gray clay pebbles and fragments disseminated irregularly throughout; grading into (j_1)	1.5
	j_1. Same as (j_3); grading into (i_3)	2.6
i.	i_3. Firm, light chocolate-brown, poorly bedded, slightly bentonitic and carbonaceous, sandy clay; grading into (i_2)	2.0
	i_2. Firm to loose and soft, gray to light chocolate-gray where carbonaceous, unbedded to poorly bedded, clayey sand, becoming more clayey in lower part; limonite-stained to rusty reddish-yellow color locally on surface	2.8
	i_1. Firm to loose, light gray to chocolate-gray, poorly to lenticularly bedded clayey sand interbedded with firm, gray thin- to lenticular-bedded silty clays up to 0.5 inch in thickness	3.0
h.	Firm, light gray, unbedded, irregularly breaking, bentonitic, silty clay with silty sand inclusions	1.3
g.	Friable to firm and indurated, light gray, unbedded clayey sand, forming resistant ledge at small waterfall in creek	1.7 to 2.5
f.	f_4. Friable, gray on fresh exposure, light gray on weathered surface, poorly bedded, irregular breaking, bentonitic, silty clay with irregular fossil worm burrows up to 1 inch in diameter, extending 1.5 feet into the clay and filled with the sand above; clay stained to blackish color on exposed surface	2.0
	f_3. Firm, light gray, poorly to lenticularly bedded clayey sand, becoming a loose, tan-gray, lenticular-bedded, locally limonite-stained, fine-	

Section 39. (Continued)

Description	Thickness Feet
grained sand interbedded with firm, gray clay layers up to 0.5 inch in thickness in the basal 2.5 feet	6.3
f_2. Firm, gray, slightly bentonitic, silty clay, tan to light gray fine-grained sand and grayish clayey silt irregularly interbedded; the silt and sand locally limonite-stained	2.0
f_1. Loose and soft, light gray to gray, rusty-yellow-stained locally, poorly bedded fine-grained sand irregularly interbedded with firm to friable, light gray, unbedded, slightly bentonitic, clayey silts	2.4
e. Firm, light gray, poorly to lenticularly bedded, conchoidally breaking, slightly bentonitic, silty clay, in upper 1.5 feet interbedded with a friable to soft, light gray, poorly bedded, clayey silt in layers up to 4 inches thick with dark chocolate-brown carbonaceous material between some bedding planes	7.3
d. Firm, rusty yellow-gray, poorly bedded to unbedded, tuffaceous, clayey sand interbedded with firm, light gray, slightly bentonitic, silty clay up to 0.5 inch in thickness; grading into (c)	0.9
c. Crumbly to soft, light to chocolate-brown, poorly bedded to unbedded, silty, carbonaceous shale; grading into (b_3)	1.4
b. b_3. Firm to friable, light tan-gray, thin- and lenticular-bedded, limonite-stained clayey silt, slightly carbonaceous along certain bedding planes, interbedded with a firm, dark gray to chocolate-gray, slightly carbonaceous, silty clay; thin limonitic laminations weathering out and fossil worm burrows up to 0.5 inch in diameter present in the clayey silt	8.2
b_2. Firm to friable, light brownish-gray on fresh exposure, light gray on weathered surface, thin-	

Section 39. (Continued)

Description	Thickness Feet
to lenticular-bedded, slight carbonaceous in parts, slightly bentonitic, silty clay interbedded with a soft, light gray, lenticular-bedded clayey silt up to 1 inch in thickness	2.0 to 2.3
b_1. Firm to friable, light gray to light chocolate-gray where slightly carbonaceous, lenticular-bedded, slightly bentonitic, clayey silt with few small oscillatory wave basins and apparent dip to the southeast, interbedded with firm, chocolate-brown, silty, carbonaceous shale partings, thin lenses and layers up to 0.5 inch in thickness; up dip interfingering with crumbly to soft, light brownish-gray, slightly bentonitic, silty clay with apparent dip to the northwest, interbedded with loose, dark gray, slightly tuffaceous, course-grained sand up to 9 inches in thickness, clayey silts up to 1.5 inches thick and layers of lignitized plant remnants up to 0.5 inch thick between some bedding planes; thin limonitic laminations weathered out on surfaces of the clayey silts	6.5
a. Soft, loose, dark gray to gray, lenticular- to cross-bedded, slightly tuffaceous, fine- to medium-grained sands with grayish-white, tuffaceous, silty material along certain bedding planes, interbedded with a firm, dark creamy, lenticular- to thin-bedded, irregular breaking, silty clay in lenses and layers up to 3 inches thick; sand locally stained to a rusty-yellow color; bottom not exposed	4.5
Total	83.3

Section 10. Manning section in banks of northeast trending tributary of Tuttle Branch, starting in head of deep gully in northeast corner of T. E. Speed land, 140 yards southwest from site of abandoned house, continuing across northeast corner of Frank Bittney land, south part of H. Wornkerr land, ending in south-central part of H. Olle land, 2.15 miles south-southeast from Muldoon post office along the Muldoon-La Grange county road, 0.95 mile south along old public road, 0.55 mile northwest along wagon trail through abandoned field; northwest corner of T. E. Speed 119.5-acre tract, uppermost northeast corner of Frank Bittney 1000-acre tract, L. W. T. Peebles survey, south parts of H. Wornkerr 30-acre tract and H. Olle 30-acre tract, Wm Higgens survey.

Description	Thickness Feet
Manning:	
s. Light tan sandy soil	1.0 to 2.0
r. Soft, tan to gray, cross-bedded sands, locally cemented due to limonite and highly stained to an orange color	3.0
q. Crumbly to sticky when wet, chocolate-brown, massive, slightly bentonitic, silty shale	1.5 to 4.0
p. p_4. Firm to friable, white, massive, tuffaceous, sandstone	0.7
p_3. Soft, light chocolate- to grayish-brown,	

Section 10. (Continued)

	Description	Thickness Feet
	carbonaceous shale	0.5
	p_2. Same as (p_4)	1.0
	p_1. Same as (p_3)	1.0
o.	Firm to friable, light to dark creamy-gray, thin- to lenticular-bedded, interbedded sandy clay and clayey sand	4.0
n.	n_3. Firm, light chocolate-gray to light gray, poorly bedded, limonite-stained silty clay with disseminated brown clay pebbles of various shapes up to three-fourths of an inch in diameter in the upper 8 feet; limonite laminations weathered out on surface	10.2
	n_2. Firm, gray, silty clay with abundant carbonaceous matter	0.5
	n_1. Firm, light chocolate-gray, massive to poorly bedded silty clay with impressions of leaves several inches long, lignitized plant fragments, some limonite staining and limonite laminations weathered out on exposed surfaces; grading into (m)	7.5
m.	Soft to somewhat indurated locally, light tan-gray to gray, cross-bedded tuffaceous sand becoming carbonaceous and clayey locally in upper part; limonite stained locally along bedding planes	4.0 to 6.0
l.	l_3. Firm, gray, poorly bedded, slightly bentonitic clay; grading into (l_2)	1.3
	l_2. Friable, light chocolate-brown to light chocolate-gray, poorly bedded, tuffaceous, silty shale with gray clay pebbles and small lenses disseminated in the upper part; presence of few fossil worm burrows; grading into (l_1)	11.0
	l_1. Soft, chocolate-brown, poorly bedded, limonite-stained on weathered surface, silty, tuffaceous,	

Section 10. (Continued)

Description	Thickness Feet
lignitic shale with sulphur-yellow-colored copiapite, flat, radial, gypsum crystal rosettes and with abundant fossil worm burrows up to three-fourths of an inch in diameter, vertical to horizontal in position; less lignitic in upper part	7.8
k. Firm, light chocolate-brown to light gray, poorly bedded, carbonaceous shale locally with a 3-inch layer near the top and chunks at a lower level of an indurated, white, tuffaceous, fine-grained sandstone at a lower level; presence of the silicified remnants of a flat, white, silicified log 15 feet long, fine sulphur-yellow copiapite on surfaces and in small joints, abundant flat, radial, gypsum crystal aggregates, small chunks of friable, black lignitic wood; the white tuffaceous sandstone is absent down dip to the south	2.7
j. j_3. Soft, light tan to light gray, poorly bedded, limonite-stained, tuffaceous sand up to 4 inches in thickness interbedded with friable, dark, cream-colored, silty clays and clayey sands; grading into (j_2)	6.3
j_2. Firm to friable, light chocolate-brown, carbonaceous, silty shale with gray clay and tuffaceous sand disseminated in lower part, with lignitic plant fragments; grading into (j_1)	3.0
j_1. Firm, dark gray to gray, massive, conchoidally to irregular breaking, slightly carbonaceous, slightly bentonitic clay with lignitized plant fragments	2.0
i. Soft to somewhat indurated locally, gray, cross-bedded, tuffaceous sand becoming lenticular and clayey in upper part	4.3
h. Firm, light gray, conchoidally breaking, poorly bedded, bentonitic, silty clay in upper 1.3 feet, grading down into a soft, dark chocolate-brown on fresh exposure, light chocolate-brown on weathered surface, poorly bedded, highly carbonaceous	

Section 10. (Continued)

Description	Thickness Feet
shale with flat, lignitized wood fragments up to 1 inch in width and 3 inches in length; shale and clay with abundant gypsum crystal aggregates in irregular forms and shapes up to 3 inches in diameter, weathering out on exposed surfaces	3.0
g. Friable, white, tuffaceous, silty clay	0.3 to 0.5
f. Firm to friable, brown to black, poorly bedded, highly carbonaceous shale	1.5
e. Same as (g)	0.3 to 0.5
d. Firm, dark grayish, irregular breaking, slightly bentonitic clay, swelling when wet	4.2
c. c_4. Soft, whitish-gray, massive, tuffaceous, silty clay	0.8
c_3. Soft, sticky, dark chocolate- to blackish-brown, poorly bedded, highly carbonaceous shale with lignitized plant remains	0.5
c_2. Same as (c_4)	1.5
c_1. Same as (c_3)	1.3
b. Soft, tan to gray, poorly bedded, tuffaceous sand and clayey sand interbedded with firm, dark gray, thin-bedded, highly bentonitic clay layers up to 0.5 inch in thickness	3.3
a. Friable, grayish-brown on fresh exposure, brownish-tan on weathered surface, massive tuffaceous clayey sand with brown clay partings and clayey material disseminated throughout bottom not exposed	1.0
Total	96.9

Section 9. Manning-Whitsett section in banks of Tuttle Branch, starting in northeast part of M. Loth land, 15 yards west of old wooden bridge, continuing east-southeast across corner of C. Henson land, across west part of Chas. Loth land, through central part of A. Browning land into and ending near the center of south boundary of E. Gerbert land, 2.15 miles south-southeast of Muldoon along Muldoon-La Grange county road, 0.28 mile south along old public road to wooden bridge; northeast part of M. Loth 50-acre tract, southwest corner of C. Henson 54-acre tract, west part of Chas. Loth 50-acre tract, Wm. Higgens survey, central part of A. Browning 103-acre tract, J. M. Ferrell survey, central part of E. Gerbert 37.5-acre tract, Noah Carnes survey.

Description	Thickness Feet
Lower Whitsett:	
z. Light brownish-gray, clayey sand soil	1.0 to 2.0
y. Soft, light gray, lenticular- and cross-bedded, tuffaceous sand in lenses up to 1.5 feet thick interbedded with firm, tan, limonite-stained, lenticular-bedded, clayey sand and sandy clay; sands rest on level-bedded Manning clay	9.1
Upper Manning:	
x. Friable, light to dark gray, slightly bentonitic, thin-bedded silty clay with limonite-staining on	

Section 9. (Continued)

	Description	Thickness Feet
	exposed surface; grading into (w)	2.0
w.	Soft, brown to black, poorly bedded lignitic shale; grading into (v)	0.5
v.	Friable to soft, light tan, poorly bedded, tuffaceous, clayey sand with sandy shale in the upper foot; grading into (u_2)	2.5
u.	u_2. Friable, light chocolate-brown, poorly bedded, tuffaceous, carbonaceous, silty shale; grading into (u_1)	1.0
	u_1. Soft, brownish-black, poorly bedded, lignitic shale with a 3-inch layer of white, tuffaceous sandstone near the top; grading into (t)	2.0
t.	Soft, tan to gray, lenticular- to cross-bedded, fine-grained sand in lenses up to 1.5 feet in thickness with brownish carbonaceous matter in thin zones and limonite-stained along bedding planes, interbedded with a friable, light gray, thin- to lenticular-bedded, slightly bentonitic, tuffaceous, sandy clay; grading into (s)	8.3
s.	Firm to crumbly, waxy, dark chocolate-brown on fresh exposure, light chocolate-brown on weathered surfaces, thin- to massive-bedded, lignitic shale; upper foot brownish-gray, less lignitic and more sandy	17.1
r.	r_4. Friable, white, tuffaceous sandstone	0.5 to 1.0
	r_3. Lignitic shale; grading into (r_2)	1.0
	r_2. Friable, light brownish-gray, massive, tuffaceous, lignitic, sandy clay; grading into (r_1) .	2.0
	r_1. Friable, light gray, thin- to lenticular-bedded, tuffaceous, clayey sand, locally light brown and limonite-stained	2.0
q.	Soft, light chocolate-brown, massive, tuffaceous, carbonaceous, clayey sand with small lignitized plant fragments	2.0

Section 9. (Continued)

	Description	Thickness Feet
p.	Firm, white, tuffaceous sandstone, carbonaceous in lower 5 to 7 inches; forms upper ledge of small waterfall in creek; rests on undulating surface of (o)	2.5
o.	Soft, light to dark chocolate-brown, poorly bedded, carbonaceous to lignitic shale with lignitized plant fragments, abundant fossilized root and stem impressions, and hard, dark brown, round clay pebbles up to one-fourth of an inch in diameter	1.5
n.	Firm to friable, grayish-white, massive- to somewhat lenticular-bedded locally, tuffaceous sandstone with vertical fossil stem impressions; forms lower ledge of waterfall in creek	1.0 to 2.0
m.	m_2. Firm, light yellowish-gray, poorly bedded, tuffaceous, sandy clay locally with carbonaceous to lignitic shale in uppermost 0.5 foot; grading into (m_1)	3.5
	m_1. Firm to crumbly, sticky when wet, dark gray on fresh exposure, light gray on weathered surfaces, slightly carbonaceous and bentonitic clay; grading into (l_2)	3.5
l.	l_2. Firm, chocolate-brown on fresh exposure, light brown on weathered surface, poorly bedded silty shale with lignitized plant fragments and abundant white fossil plant, reed and stem impressions up to 2 inches in length; weathers into thin flaks on surface; grading into (l_1)	2.0
	l_1. Firm, light chocolate-brown on fresh exposure, light gray on weathered surface, poorly bedded, bentonitic, silty clay with few layers of light brown clay up to one-fourth of an inch in thickness; rests on a somewhat wavy surface of (k)	3.0
k.	Loose, light gray to gray with a greenish tint, even- to cross-bedded, tuffaceous, medium-grained sand with carbonaceous layers up to 0.5 inch in thickness between individual sand layers; limonite-stained	2.0

Section 9. (Continued)

Description	Thickness Feet
j. Friable, light brown to tan, poorly to thin-bedded, tuffaceous, clayey sand; grading into (i)	1.5
i. Firm, light chocolate-brown to tan-gray, poorly bedded sandy shale becoming a carbonaceous shale toward base with lignitic plant fragments in basal 2 feet	3.0
h. Soft to crumbly, light brown to brownish-black, poorly bedded lignitic shale with lignitized plant fragments and long, slender fossil root impressions filled with a dark, carbonaceous material; contains an irregular bed of soft, white, tuffaceous sandstone up to 6 inches in thickness in the middle; grading into (g_3)	1.0 to 2.0
g. g_4. Firm to friable, light gray, lenticular-bedded, tuffaceous, fine-grained sands, creamy-gray, tuffaceous, sandy clay and clay sand intermixed; grading into (g_3)	3.2
g_3. Firm, brownish-gray on fresh exposure, creamy-gray on weathered surface, thin- to lenticular-bedded, slightly bentonitic, tuffaceous, silty shale in lenses up to 1.0 foot thick with few lignitized plant fragments interbedded with soft, light gray, cross-bedded tuffaceous sands; grading into (g_2)	5.5
g_2. Firm to loose, light tan-gray to dark gray, cross- to lenticular-bedded tuffaceous sand limonite-stained locally and along bedding planes, with small lenses of a light to dark creamy-gray, bentonitic and silty clay at the base; sand contains fossil worm burrows locally; grading into (g_1)	23.0
g_1. Firm to loose, light tan-gray, light greenish-gray to dark gray, cross- and lenticular-bedded sand limonite-stained and limonite laminations weathering out locally, interbedded in the upper part with a firm, light chocolate-brown, sandy shale, and a light to dark creamy-gray to choco-	

Section 9. (Continued)

	Description	Thickness Feet
	late-brown, thin-bedded, locally undulating, slightly bentonitic, tuffaceous, silty to sandy clay in the lower part; presence of a 2-foot zone, 4 feet above the base of the cross-bedded sand riddled with rough, irregular fossil worm burrows up to 0.5 inch in diameter, filled with clayey material from clay bed above	10.3
f.	f_2. Firm to friable, yellowish-tan-gray, lenticular-bedded, sandy clay; grading into (f_1)	1.0
	f_1. Firm to friable, light to dark chocolate-brown, more silty in top part, lenticular-bedded, silty shale with thin lenses of silty clay, limonite-stained, irregular small worm burrows filled with blackish-brown, carbonaceous shaley material, and locally with yellow copiapite	9.0
e.	e_4. Firm, whitish-gray, tuffaceous sand traversed by fossil worm burrows filled with light brown clayey material from above	0.3
	e_3. Firm, light to dark chocolate-colored clayey sand; grading into (e_2)	0.3
	e_2. Firm, light chocolate-brown, poorly bedded, sandy to silty shale; grading into (e_1)	0.7
	e_1. Friable, chocolate-brown to black, poorly bedded, carbonaceous shale with lignitized plant fragments	0.3
d.	d_4. Firm, white on fresh exposure, whitish-gray on weathered surface, poorly to massive-bedded, tuffaceous fine-grained sand	1.5
	d_3. Firm to friable, chocolate-brown to brownish-black on fresh exposure, light chocolate-brown on weathered surface, thin-bedded, carbonaceous to lignitic silty shale with lignitized plant fragments	0.5
	d_2. Same as (d_4)	1.5

Section 9. (Continued)

	Description	Thickness Feet
	d_1. Same as (d_3) but more carbonaceous and less shaley	0.8 to 1.5
c.	c_2. Firm, light tan-gray, poorly bedded, tuffaceous, shaley sand with abundant fossil root impressions filled with dark brown shale from above, interbedded with thin layers of brown shale; grading into (c_1)	1.3
	c_1. Same as (c_2) except friable, less shaley and without fossil root impressions	1.2
b.	Firm to loose, light tan to light chocolate-brownish-tan, thin- to locally lenticular-bedded fine-grained sand and clayey sand up to 8 inches thick with undulating upper surfaces, interbedded with firm, light gray, thin-bedded silty shale and limonite-stained silty sand up to 9 inches thick; presence of a 1.5-foot zone of interbedded sand and sandy clay in small oscillatory wave basins, 0.5 to 1.0 feet above the base	8.0
a.	Firm, light to dark chocolate-brown on fresh exposure, light brownish-gray on weathered surface, thin-bedded, conchoidally to irregularly breaking, slightly bentonitic and silty shale with silt partings, limonite staining, and with long, slender gypsum crystals and crystal aggregates weathered out on surface; upper 0.5 foot of shale interbedded with clayey silt; bottom not exposed	8.0
	Total	156.1

Section 5. Manning-Whitsett-Catahoula section in banks of Black Branch, starting 140 yards east of southwest corner of T. Parker land, continuing east-southeast through D. Hoopman land, across extreme northeast corner of Garbode land into Faulkerson land, ending in head of shallow gully 450 yards east of west boundary or 84 yards west of fence line on edge of abandoned field; 3.37 miles south-southeast along Farm road No. 154, 1.8 miles due east along Old La Grange road, 0.9 mile southeast to Black Branch from entrance wire gate across the road from old abandoned house, or 4 miles S. 5° E. of Muldoon, airline distance; southwest corner and south part of T. Parker 108-acre tract, south part of D. Hoopman 48-acre tract, extreme northeast corner of Garbode land, center of west part of C. W. Faulkerson 260-acre tract, northeast corner of B. Green survey.

	Description	Thickness Feet
Lower Catahoula:		
Dd.	Grayish-brown clayey soil	1.0
Cc.	Firm to hard, light gray to gray on fresh exposure, dark gray to grayish-black on weathered surfaces, massive, irregular breaking, tuffaceous sandstone; resistant to weathering	2.2
Bb.	Firm to friable, light gray to dark creamy-colored, massive, slightly bentonitic, tuffaceous, sandy clay	9.3

Section 5. (Continued)

Description	Thickness Feet
Aa. Soft to slightly indurated due to cementation by tuffaceous material, light gray to dark gray, cross-, lenticular- to massive-bedded tuffaceous sand, limonite-stained locally with cream-colored, bentonitic clay pebbles up to 0.5 foot in diameter disseminated throughout some layers and along certain bedding planes, with rough, irregular fossil borehole pipes, limonitic laminations and concretions weathering out locally with tuffaceous material more resistant to weathering and concentrated along certain bedding; presence of silicified logs, stumps and wood fragments up to 3 feet in diameter; sands rest on wavy surface of the Whitsett clays	26.0
Disconformity	
Whitsett:	
z. Firm, whitish-gray, conchoidally breaking, poorly-bedded bentonitic clay grading down into firm, light chocolate-brownish-gray to chocolate-brown, silty clay; silt concentrated locally in small pockets ..	6.0
y. Firm, light gray, massive-bedded, irregular breaking, sandy clay locally limonite-stained	11.0
x. Firm, light chocolate-brownish-gray, poorly bedded, slightly muscovitic, tuffaceous, clayey sand with flat chocolate-brown shale partings and few round pebbles up to 1 inch in diameter; small irregular limonite-stained blotches on exposed surface; forms smooth V-shaped creek banks	9.0
w. Firm to loose, light gray to dark gray, cross- to lenticular-bedded tuffaceous sand up to 2 feet in thickness with small clay pebbles, interbedded locally with light gray, thin-bedded bentonitic	

Section 5. (Continued)

	Description	Thickness Feet
	clay and shale layers up to 1.5 feet in thickness; sand slightly to very limonite-stained locally	15.0
v.	Loose, dark gray on fresh exposure, light yellowish-gray on weathered surface, cross-bedded and laminated, tuffaceous sand with irregular breaking, brown clay pebbles up to 4 inches in length; presence of a friable, creamy-white, bentonitic clay lense 0.5 to 1 foot thick and several feet long, 1.3 feet above base of sand unit	5.0
u.	Firm to friable, light brownish-gray on fresh exposure, creamy-gray on weathered surface, thin- to lenticular-bedded, bentonitic, silty clay interbedded with soft, grayish, lenticular-bedded sand lenses up to 4 inches in thickness	13.0
t.	Loose, light brown to dark gray, lenticular- to cross-bedded, tuffaceous, carbonaceous sand 1 to 2 feet in thickness interbedded with irregular lenses of light brownish-gray, bentonitic clay ..	2.0
s.	Clay similar to (u) interbedded with waxy, light brown clay and thin lenses of grayish, tuffaceous sand	4.0
r.	Friable, light brown sandy clay	2.0
q.	Soft, light gray, thin-bedded, clayey, tuffaceous sand with whitish-gray clay pebbles; grading into (p)	1.0
p.	Firm to friable, light chocolate-brown to light gray, thin-bedded sandy clay; grading into (o) ..	2.0
o.	Firm, light tan, thinly-bedded, tuffaceous clayey sand with limonite-staining along bedding planes	3.0
n.	Firm, light chocolate-brown, conchoidally breaking, thinly-bedded, slightly silty and bentonitic clay	0.6

Section 5. (Continued)

Description	Thickness Feet
m. Firm to soft, light tan to gray, thin- to cross-bedded, tuffaceous, fine-grained sand with limonite staining along certain planes; resting on sharply dipping Manning clays	0.8
Upper Manning:	
l. Firm, light brown, conchoidally breaking, poorly bedded, bentonitic, silty clay	3.0
k. Soft, dark gray, poorly bedded tuffaceous sand with firm, light chocolate-brown clay partings and irregular pebbles disseminated throughout ...	2.5
j. Friable to firm, crumbly, whitish-gray, massive, tuffaceous bed with pumiceous appearance and very undulating, wavy surfaces; forms resistant ledge protruding from creek bank	0.5
i. Soft to partial indurated locally at top, dark gray on fresh exposure, light gray on weathered surface, cross-bedded tuffaceous sand with limonite laminations of a reddish-yellow color along some bedding planes and riddled by fossil worm burrows very concentrated locally, with rough, irregular outlines, vertical to horizontal in position, filled with the enclosing stained to unstained sand, or with a white clayey material ..	3.0
h. Soft to firm, tan, light gray to gray, cross- to lenticular-bedded tuffaceous sands locally highly limonite-stained, with oblong to flat sandy clay to clayey sand pebbles up to 1 inch in diameter and irregular fossil worm burrows up to 1.5 inches in diameter and 1 foot in length; sand interbedded with a firm, brown when fresh, light gray on weathered surfaces, slightly bentonitic and carbonaceous clay up to 4 inches thick; presence of highly tuffaceous sand up to 1 inch in thickness between individual sand layers	22.1

Section 5. (Continued)

Description	Thickness Feet
g. Soft, light tan to light gray, thin-, lenticular- to cross-bedded, tuffaceous, fine-grained sand up to 1 foot in thickness, interbedded with friable to firm, light chocolate-gray to light brown and brown on fresh exposure, creamy-white where weathered, conchoidally breaking, thin-bedded, slightly carbonaceous clay and tuffaceous, silty clays up to 3 inches in thickness and soft, grayish-white tuffaceous material in fragments up to 8 by 12 inches which do not disrupt the clay bedding planes; forms almost vertical creek banks locally	15.5
f. Firm to soft, light yellowish-tan to light brownish-gray, poorly-bedded, tuffaceous, fine-grained sands limonite-stained to yellowish-red color, interbedded with firm, light brown on fresh exposure, blackish on weathered surfaces, conchoidally breaking, slightly carbonaceous clay up to 1 inch in thickness; clay also disseminated throughout sand	4.0
e. Soft, light brownish-tan to light yellowish-tan, thin- to massive-bedded, tuffaceous, clayey sand with lignitized plant fragments, gypsum crystals, and brown to chocolate-brown carbonaceous clay disseminated throughout	5.0
d. Firm, light brownish-gray on fresh exposure, light gray on weathered surface, massive-bedded, slight bentonitic, tuffaceous, sandy clay with poorly silicified wood weathering out; down dip 30 yards the clay becoming a soft, chocolate-brown to dark brownish-black, lignitic shale with light grayish-white, poorly silicified logs up to 4 feet long and 1 foot in diameter protruding from the shale	1.5
c. Soft, tan to gray, lenticular- to cross-bedded, tuffaceous sand with firm, light gray, slightly bentonitic clay layers up to 0.5 inches in thickness	8.3
b. Friable, tan, thin-bedded, tuffaceous, sandy clay limonite-stained in the upper half, grading down into a firm, chocolate-brown on fresh exposure,	

Section 5. (Continued)

Description	Thickness Feet
light chocolate-brown on weathered surface, thin-bedded, slightly carbonaceous, silty shale with clayey silt and sand confined mostly between bedding planes	5.0 to 6.0
a. Soft, light chocolate-brown, tuffaceous, clayey sand with brown clay pebbles; somewhat reworked by fossil worm burrows; bottom not exposed ...	5.0 to 6.0
Total	190.3

Section 1. Manning-Whitsett section in banks of Blackjack Branch, 3.08 miles north-northeast from Muldoon post office or 1.58 miles east from Wrightman Crossing along county road to Wrightman abandoned house, 1.4 miles south-southeast from entrance fence gate along private trail past W. Jurika's house to abandoned house, 250 yards south across abandoned field, or 2.6 miles S. 73° E. of Muldoon, airline distance; starting 100 yards east of west boundary of Martin Smith survey, continuing east past abandoned house; east to central part of Herman Kempe 338.5-acre tract, Martin Smith survey.

Description	Thickness Feet
Lower Whitsett:	
k. Light brown sandy clay soil	1.0
j. Firm to friable, gray to grayish-brown, thin- to massive-bedded, tuffaceous, sandy clay and sandy shale interbedded with gray, tuffaceous, fine-grained sand up to 1.5 inches thick; limonitic laminations and occasional limonitic concretions weathering out along bedding planes; uppermost foot of unit consists of a soft, chocolate-brown, lignitic shale interbedded with soft, grayish-brown, carbonaceous, tuffaceous sand	11.2
i. i_3. Soft, brown to black, lignitic shale with a white, tuffaceous, fine-grained sand up to 1 foot thick and tuffaceous sand boulders up to 0.5 foot in diameter; boulders are 1 foot below the sand layer; grading into (i_2)	3.0
i_2. Firm to friable, light brown to chocolate-	

Section 1. (Continued)

	Description	Thickness Feet
	brown, carbonaceous, tuffaceous shale; grading into (i_1)	2.2
	i_1. Firm, light gray, poorly bedded, tuffaceous sandy clay intermixed with some clayey sand; grading into (h)	0.8
h.	Soft, tan to gray, cross-bedded tuffaceous sand .	5.5
g.	Firm, light gray to gray, massive, irregular breaking, slightly carbonaceous, bentonitic, clay up to 0.5 foot thick interbedded with soft, dark gray, lenticular-bedded, tuffaceous, fine-grained sand lenses and firm, light chocolate-brown, poorly bedded, carbonaceous, tuffaceous sandy clay layers up to 1 inch and 1 foot in thickness, respectively	9.0 to 11.0
f.	Soft, gray, massive, tuffaceous sand with firm to friable, light gray to cream-colored, slightly bentonitic, sandy clay pebbles and boulders up to 3 feet in diameter; their bedding planes horizontal to vertical in position	7.5
e.	Firm, brownish-gray, poorly to massive-bedded, slightly carbonaceous, bentonitic clay weathering to a yellowish-brown color	6.0
d.	Friable, light gray, thinly to poorly bedded, slightly bentonitic, silty clay interbedded with soft, gray, lenticular-bedded tuffaceous sands ..	5.3
c.	Soft, gray to greenish-gray, lenticular- to cross-bedded, tuffaceous, fine-grained to medium-grained sands, with lignitized plant fragments along some bedding planes	13.0

Upper Manning:

b. Firm, light gray, lenticular-bedded, silty, bento-

Section 1. (Continued)

Description	Thickness Feet
nitic clay interbedded with soft, gray to chocolate-brown, poorly bedded, tuffaceous, lignitic sand in lenses up to 0.7 foot thick; grading into (a)	8.0
a. Firm and waxy, dark brown carbonaceous clay; bottom not exposed	5.0
Total	79.5

Section 15. Catahoula section in banks of Gorham Branch and tributary heading in southeast corner of N. R. Cole land, continuing north 2200 feet past south boundary of Jesse Bartlett survey and high tension line into northwest corner of J. A. Kerr land, 3.9 miles northeast of Muldoon post office along county dirt road, 0.83 mile south from corner wire gate along wagon trail to high tension line, 900 feet west along the line to branch, or 3.4 miles east of Muldoon, airline distance; west and northwest part of J. A. Kerr 66-acre tract, southeast part of Jesse Bartlett survey and east part of N. R. Cole 136-acre tract, northwest corner of Theo. O. Berry survey.

Description	Thickness Feet
Lower Catahoula:	
w. Light brown-gray, sandy clay soil	0.5 to 1.0
v. Gray weathered clay, poorly exposed	1.5
u. u_2. Loose to soft, light gray on fresh exposure, dark gray on weathered surface, cross-bedded, tuffaceous, fine-grained sand with fossil worm burrows up to 1 inch in diameter, irregular outer surfaces and limonite-stained to reddish-yellow color	11.0
u_1. Soft, light gray, lenticular- and cross-bedded, tuffaceous, fine-grained sand up to 2 feet thick interbedded with friable, light creamy-gray, slightly bentonitic, sandy clay; limonite laminations at top of the clay lenses	6.0

Section 15. (Continued)

	Description	Thickness Feet
t.	t_3. Firm, dark gray on fresh exposure, light gray on weathered surface, thin-bedded, conchoidally breaking, slightly bentonitic, silty clay interbedded with light gray, thin-bedded, sandy clay ..	2.5
	t_2. Firm, dark gray, thinly to poorly bedded, slightly bentonitic clay interbedded with silty clay; upper 4 inches a light tan, limonite-stained, clayey sand	2.5
	t_1. Similar to (t_3) but more silty, poorly bedded, and locally with light gray, sandy clay lenses up to 1 foot thick; more resistant to erosion, locally protruding slightly from steep creek banks; becoming more waxy upward	12.3
s.	Firm, light chocolate-gray to tanish-gray on fresh exposure, light gray on weathered surface, poorly bedded, sandy clay; locally carbonaceous and limonite-stained; grades into (r)	1.5
r.	Crumbly and waxy, gray to dark gray, poorly bedded, slightly bentonitic, carbonaceous clay with a 0.5-foot layer of lignitic shale in middle	1.3
q.	Loose, gray, massive, tuffaceous, fine-grained sands with a 3-inch layer of soft, dark chocolate-brown, lignitic sand at base; locally with a similar layer in middle of bed	1.7
p.	Loose, gray to dark gray, cross- and lenticular-bedded, tuffaceous, round to subround, fine- to medium-grained sands locally highly limonite-stained, with firm to friable, light tan, poorly bedded, sandy clay up to 0.5 foot thick and firm, creamy, slightly bentonitic clay up to 0.3 foot thick; upper 3 feet of sand with fossil worm burrows up to 0.5 inch in diameter, with outer surface rough, irregular and of more tuffaceous material; small lenses of a whitish gray, tuffaceous material in upper 0.9 foot of sand and a 0.5-inch layer of similar material at top of bed ..	16.5
o.	Friable, to soft, light tan, lenticular-bedded,	

Section 15. (Continued)

	Description	Thickness Feet
	tuffaceous clayey sands with a 4-inch layer of firm, brown, conchoidally breaking, slightly carbonaceous clay at the base interbedded with a firm, light gray, slightly bentonitic, silty clay up to 4 inches thick and thin layers of a creamy, slightly bentonitic clay; occasional firm, creamy-white, bentonitic clay lenses 1 foot long and 1 inch thick, and locally oscillatory wave basins up to 5 feet in length and 0.8 foot in depth are present in the clayey sand	5.0
n.	n_5. Firm, indurated, light gray, massive to poorly bedded, tuffaceous sandstone	0.2
	n_4. Friable, light brownish-gray, poorly bedded, slight bentonitic and carbonaceous clay, locally replaced by indurated sand lenses	0.3
	n_3. Same as (n_5)	0.2
	n_2. Friable, light tan to tan-gray, thinly to poorly bedded sandy clay; grading into (n_1)	0.7
	n_1. Firm, waxy, dark gray to dark brown on fresh exposure, light gray on weathered surface, poorly bedded, conchoidally breaking, slightly carbonaceous and bentonitic clay with firm, tanish-gray, highly stained lenses of sandy clay up to 2 feet in length and 6 inches in thickness	3.0
m.	m_3. Hard, indurated, gray, lenticular-bedded, tuffaceous sandstone up to 1.2 feet thick forming uppermost ledge of waterfall, with abundant ripple marks on exposed upper surface increasing in size and depth toward top; 20 yards up dip in west creek bank, sandstone decreases to 0.8 foot in thickness and rests on undulating surface of (m_2)	0.8 to 1.2
	m_2. Firm, light brown on fresh exposure, light chocolate-gray on weathered surface, poorly bedded, conchoidally breaking, slightly bentonitic clay up to 0.8 foot thick with undulating upper surface; 20	

Section 15. (Continued)

Description	Thickness Feet
yards up dip and in side of vertical west creek bank, clay replaced by 1 foot of loose, gray, tuffaceous sands	0.8 to 1.0
m_1. Hard, indurated, gray, lenticular-bedded sandstone up to 2.5 inches thick interbedded with clay similar to (m_2) up to 2 inches in thickness	1.2
l. Soft, loose, dark gray on fresh exposure, light gray on weathered surface, massive, round to subround, tuffaceous, fine-grained sand	3.3
k. Firm, indurated, light chocolate-brown to brownish-gray on fresh exposure, light gray on weathered surface, poorly bedded, tuffaceous sandstone with carbonaceous matter and partings disseminated throughout; small pelecopod casts and limonite staining on exposured surfaces; sandstone forms a resistant, projecting ledge at waterfall and breaks off in irregular slabs	2.5
j. Loose, gray, massively bedded, round to subround, medium-grained sands; tuffaceous in upper 0.5 foot and with disseminated flat, brown clay pebbles up to 2 inches in length; resting on even, level-bedded Whitsett clays	4.8
Disconformity	
Upper Whitsett:	
i. i_2. Firm, brown on fresh exposure, light chocolate-brown on weathered surface, poorly bedded, to unbedded, conchoidally breaking, bentonitic, slightly silty clay with limonite staining, copiapite and locally with flat gypsum crystal aggregates up to one-fourth of an inch in thickness	7.0

Section 15. (Continued)

	Description	Thickness Feet
	i_1. Firm to gummy and coherent, brown to black on fresh exposure, light brown on weathered surface, conchoidally breaking, bentonitic, carbonaceous clay with small inclusions of a black odorless and tasteless, viscous fluid, abundant copiapite and gypsum rosettes; upper half of bed deep dark bluish-black and very coherent	4.7
h.	h_4. Friable to firm, black, poorly bedded lignite with small inclusions of hard, black coal, abundant copiapite, and gypsum crystals in irregular aggregates and laminae	2.5
	h_3. Firm, brownish-black to black, poorly bedded to unbedded, lignitic shale with abundant lignitized plant fragments, copiapite, and gypsum crystals and aggregates	0.8
	h_2. Crumbly and sticky when moist, firm when dry, dark brown to brownish-black on fresh exposure, dark brown on weathered surface, poorly bedded to unbedded lignitic shaley clay with abundant small tabular gypsum crystals, copiapite and limonite staining locally; more lignitic in lower half ...	2.9
	h_1. Soft, chocolate-brown to brownish-black, unbedded, carbonaceous to lignitic, silty shale grading down dip into a good grade of fairly hard, black lignite; the lignite beds increase up to 2.0 feet in thickness and alternate with firm to friable, grayish-white to light chocolate-brown where weathered, poorly bedded, tuffaceous, silty clay becoming more lignitic and increasing down dip to a thickness of 1.0 foot; locally of a whitish color and less lignitic, with worm borings, lignitized wood fragments, reed and stem impressions, and abundant copiapite; presence of a silicified palm log 1.5 feet long, 9 inches broad, and 3 inches thick in the tuffaceous, silty clay locally indurated and forming a resistant projecting ledge in creek bank	7.8
g.	g_2. Firm, dark greenish-gray on fresh exposure,	

Section 15. (Continued)

	Description	Thickness Feet
	light gray on weathered surface, poorly bedded, conchoidally breaking, bentonitic clay, limonite-stained on exposure; grading into (g_1)	4.0
	g_1. Friable to soft, light chocolate to brownish-black, poorly bedded, lignitic shale; the basal foot becoming a firm, chocolate-brown, carbonaceous clay; grading into (f_3)	2.5
f.	f_3. Friable, gray, poorly bedded sandy clay 1.7 feet thick; the upper 6 inches a firm, dark gray, poorly bedded bentonitic clay with stem and reed impressions, grading down into a friable, tan to gray, thinly to poorly bedded, tuffaceous, clayey sand with lignitic shale laminae up to 0.5 inch thick; both the tuffaceous clayey sand and the sandy clay becoming lignitic down dip	5.0
	f_2. Firm to friable, light chocolate-brown, thin-bedded, carbonaceous shale interbedded with lenses of soft, tan, tuffaceous sand up to 0.5 inch thick; carbonaceous matter more concentrated along certain bedding planes	0.8
	f_1. Friable, dark tan, lenticular-bedded, limonite-stained, tuffaceous clayey sand with undulating lower surface; grading into (e_3)	0.5
e.	e_3. Friable, chocolate-brown, thin- to lenticular-bedded, irregular breaking, tuffaceous, silty, lignitic shale with white leaf and stem impressions up to 2 inches long, few limonite concretions, sulphur-yellow copiapite; interbedded with loose, tan, tuffaceous, fine-grained sand lenses up to 0.5 inch in thickness, locally with brown, carbonaceous matter concentrated along bedding planes	5.1
	e_2. Firm to friable, light chocolate-brown to light gray, massive, irregular breaking, highly bentonitic, silty clay with fossil reeds filled with brown shaley material from (e_3); grading into (e_1)	3.4
	e_1. Same as (e_3) except poorly bedded and with absence of tuffaceous sand lenses; grading into (d_3)	14.5

Section 15. (Continued)

Description	Thickness Feet
d. d_3. Friable to soft, grayish-white, thin- to massive-bedded, tuffaceous, fine-grained sands with fossil worm burrows up to three-fourths of an inch in diameter filled with brown, lignitic shale from (e_1), with leaf impressions up to 3 inches long and 1 inch wide, and with undulating lower surface; forms resistant ledge in south creek bank; down dip becoming a friable, light chocolate-brown, even-bedded, thin- to lenticular-bedded, lignitic, tuffaceous, clayey sand up to 5.5 feet thick interbedded with a loose, gray, tuffaceous sand in lenses up to 1 inch in diameter; locally with lignitic sand layers up to 1.5 inches in thickness	5.5
d_2. Soft, light brownish to brownish-black, poorly bedded, lignitic shale	0.5
d_1. Similar to (d_3); does not change down dip ...	1.0 to 1.5
c. Firm, light brown on fresh exposure, brownish-gray on weathered surface, massive, irregular breaking, bentonitic clay; limonite-stained on exposure	1.5 to 2.0
b. Friable to soft, light tan-gray, lenticular-bedded, tuffaceous, clayey sand limonite-stained locally with brown clay partings and lenses up to 0.5 inch thick; contains limonite concretions up to 1 inch in diameter filled with tan, loose sand	5.0
a. Firm, light brown-gray on fresh exposure, light grayish on weathered surface, poorly bedded, conchoidally breaking, slightly bentonitic, silty clay; bottom not exposed	3.0
Total	160.2

Section 21. Catahoula section in small north-trending tributary of Gorham Branch, 3.9 miles northeast of Muldoon post office along county road, 1.6 miles south from corner wire gate along wagon trail, or 3.8 miles east of Muldoon, airline distance, center of south line of M. H. Brown 136-acre tract, northwest corner of Thos. O. Berry survey.

Description	Thickness Feet
Catahoula:	
h. Light brownish-black, clayey sandy soil	1.5
g. Soft, light creamy-gray, lenticular-bedded, highly bentonitic, clayey silts interbedded with loose, dark gray, tuffaceous, fine-grained sand and lenticular lenses of silty clay up to 3 inches thick with deep yellow limonite concretions up to 1 inch in diameter	5.0
f. Loose, dark gray, cross-bedded to massive-bedded, sub-round to round, medium-grained quartz sand with few hard, indurated, dark gray, somewhat rounded tuffaceous sandstone boulders up to 3.5 feet in diameter, limonite-stained to yellowish color on exposed surfaces	4.7
e. Loose to friable, light gray, unbedded, tuffaceous, fine-grained sands interbedded with firm, gray, unbedded, slightly bentonitic, silty and sandy clay limonite-stained locally and irregular lenses of firm, greenish-gray, silty clay	5.7
d. d_2. Firm, light to dark gray on fresh exposure, light gray on weathered surfaces, poorly bedded, conchoidally breaking, more silty in upper 3 feet, slightly bentonitic, silty clay with a 3-inch layer of tuffaceous, carbonaceous, sandy clay	3

Section 21. (Continued)

Description	Thickness Feet
feet below top; locally limonite-stained on exposure; lime nodules scattered on the surface; grades into (d_1)	9.5
d_1. Friable, light to dark gray on fresh exposure, light gray on weathered surfaces, unbedded, tuffaceous, sandy clay	3.0
c. Soft, tan-gray, massive-bedded, becoming lenticular-bedded at base, tuffaceous, fine-grained sand with brownish, carbonaceous sand lenses up to 1.5 inches thick and irregular fossil worm burrows up to 0.5 inch in diameter; locally limonite-stained on weathered surface	3.3
b. Friable, light brown, poorly bedded, slightly bentonitic, tuffaceous, sandy clay with few small tabular gypsum crystals	2.2
a. Soft, light gray on fresh exposures, lenticular-bedded, tuffaceous, fine-grained sands up to 1.5 feet thick interbedded with firm to friable, dark creamy-gray, lenticular- to thin-bedded, tuffaceous, silty clay up to 0.8 foot thick; presences of limonitic laminations between sand and clay layers, locally weathering out; bottom not exposed	15.0
Total	49.9

Section 20. Catahoula section in small dry south-trending tributary of West Fork of Navidad River, starting at north boundary and 800 feet east of northwest corner of S. F. Knight survey, continuing 420 feet across the county road into the Philipus Kopca land, 10.7 miles southeast from Muldoon post office along the Muldoon and La Grange-Flatonia county road, or 6.8 miles northeast from the Methodist church in Flatonia, southwest corner of Theo. Hinze 404-acre tract and northwest corner of Philipus Kopca 109-acre tract, northwest corner of S. F. Knight survey.

Description	Thickness Feet
Catahoula:	
f. Light brownish-gray, clayey sand soil	1.3
e. Friable to soft, light tan to light gray, unbedded, tuffaceous, clayey sand with irregular clacareous clay lenses up to 6 inches long and 1 inch thick; grading down into more clayey sand	11.0
d. Firm to friable, light greenish-gray on fresh exposure, light gray on weathered surface, unbedded, tuffaceous, sandy clay with abundant irregular lime stringers, concretions and nodules	5.0
c. Friable, light gray, unbedded, calcareous silty clay with partings of light greenish-gray clay ..	5.5
b. Firm, light greenish-gray to light gray on fresh exposure, light gray on weathered surface, unbedded, irregular breaking, slightly bentonitic and calcareous clay	9.3
a. Firm, light gray, unbedded, irregular breaking,	

Section 20. (Continued)

Description	Thickness Feet
slightly bentonitic, tuffaceous, silty clay up to 1.5 feet in thickness interbedded with hard, whitish gray, bentonitic, very impure, irregular limestone boulders and nodules concentrated in layers up to 0.5 foot in thickness, forming upper 1.5 feet of bed; nodules and boulders scattered along floor of creek bed; bottom not exposed	11.0
Total	43.1

Section 16. Catahoula section in deep ravine, 4.1 miles southeast from Muldoon post office along the Muldoon-La Grange county road, 0.24 mile north of Muldoon-La Grange and Flatonia road junction, in central part of Frank Olle 64-acre tract, E. W. Kean survey.

Description	Thickness Feet
Upper Catahoula:	
f. Light brownish-black, sandy clay soil	2.5
e. Firm to friable, light greenish-gray, massive, tuffaceous, calcareous silty clay with white calcareous material concentrated locally in nodules and stringers	4.0
d. Firm, partly indurated to friable and soft, light to dark gray, lenticular- to cross-bedded, tuffaceous, fine-grained sand with discontinuous lenses up to 1.5 inches thick of a firm, light gray clay	3.1
c. Firm, greenish-gray to light gray, massive-bedded, irregular fracture, bentonitic clay; upper 2.5 feet becoming light gray and very silty	6.2
b. Hard, indurated, light gray to dark gray, massive-bedded, tuffaceous sandstone; forming water falls at number of places; grades into (a)	6.0
a. Firm to friable, locally indurated, light gray to dark gray with greenish tint, poorly bedded, very tuffaceous fine-grained sands with disseminated, friable, creamy gray, tuffaceous, clayey sand and light gray, bentonitic clay pebbles up to 1 inch in diameter; indurated toward top; bottom not exposed	12.0
Total	33.8

Section 17. Oakville-Catahoula section in gully, abandoned field on north side of north-sloping cuesta, 5.3 miles northeast from Muldoon post office along Muldoon-La Grange county road, 0.2 miles northwest of northeast corner in L. L. Neisner 74-acre tract, Thos. O. Berry survey.

Description	Thickness Feet
Lower Oakville:	
c. Light gray-brown sandy soil; no bedding	1.5
b. Loose to soft, loosely cemented at top, dark-gray to brownish-gray, massive- to lenticular-bedded, subangular to round, highly calcareous, medium- to large-grained sand with abundant white lime masses and rough, irregular nodules up to 3 inches in diameter; reworked shell fragments scattered on the surfaces; Oakville sands overstep the uneven eroded surface of the Catahoula clay	4.0
Disconformity	
Upper Catahoula:	
a. Friable to crumbly, dark-gray, unbedded, bentonitic, tuffaceous, silty clays with abundant irregular columns of secondary lime; bottom not exposed ...	4.0
Total	9.5

Botanical Data

Explanation

A botanical survey was made to obtain a general idea of the vegetation present in the Muldoon area. The plants were collected at various times between November 4, 1949, and October 3, 1950. The plants were placed in plant presses, dried in electrically heated driers and later identified in the botany laboratory. An attempt was made to collect all the plants present on each of the geologic formations. Results of the survey are summarized in Table 12. Both the presence and importance of the plant species found growing on each formation are indicated by field-assigned numbers.

Table 12.- Analytical distribution list of plants of the Muldoon Area, southwestern Fayette County, Texas

Name of Plant	Geologic Formational Units							
TREES & SHRUBS	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Berchemis scandens (Hill) Trel.					5			
Brayodendron texanum (Scheele) Small								4
Bumelia lanuginosa (Michx.) Pers.				4	4			
Callicarpa americana L.	5	4			4	5	5	
Carya Buckleyi var. arkansana Sarg.	5	5			4			
Carya Pecan (Marsh) Engl. & Graebn								
Celtis mississippiensis Bosc.	4	4			3		4	3
Cornus asperifolia Michx.						5		4
Cracca virginiana L.			3					
Fraxinus sp.								
Fraxinus lanceolata Borck	5	5			5			
Ilex decidua Walt.	4			4	4			4
Ilex vomitoria Ait.	3	3	4	4	4			
Juniperus virginiana L.	2	2	3	3	2	2	2	3
Maclura pomifera (Raf.) Schneider		5			5			
Morus ruba L.	4	5			4			5
Prosopis glandulosa Torr.	4	4		4	4	4	4	
Ptelea trifoliata L.					4			
Quercus marylandica Muench	2	2	3	2	2	2	2	3
Quercus nigra L.	5	5	4	4	4			
Quercus stellata Wang.	2	2	3	2	2	2	2	3
Quercus virginiana Miller	4	4	4	3	3	3	4	4
Rulac negundo (L.) A. S. Hitchc.					5			
Salix nigra Marsh	4	4			3	4	4	4
Ulmus americana L.	3	4	4	4	3	4	4	4
Ulmus crassifolia Nutt.	4	4	4	3	3		4	3
Viburnum rufidulum Raf.					5	4		4
Vitis candicans Engelm.	4	4		5	4	4		
Xanthoxylum Clava-Herculis L.				4	4		5	
FERNS								
Woodsia obtusa (Spreng.) Torr.	5							

Significance of numbers:
1=dominant; 2=subdominant; 3=frequent; 4=infrequent; 5=rare

Name of Plant GRASSES	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Argostis hiemalis (Walt.) B.S. P.				5	5			
Alopecurus geniculatus L.				5				
Andropogon furcatus Muhl.					5			
Andropogon saccharoides Swartz	4				3	3	3	3
Andropogon scoparius Michx.	2	2	3	3	3	3	2	2
Andropogon ternarius Michx.	5							
Andropogon virginicus L.					5			
Aristida sp.								
Aristida intermedia Scribn. & Ball	3	3		3	3	3	4	
Aristida longespica Poir.	2	3		3	2	2	4	
Aristida oligantha Michx.				2	3	3	3	
Bouteloua curtipendula (Michx.) Torr.					5	4	3	3
Bouteloua hirsuta Lag.	3	3	3	2	2	3	4	
Bouteloua rigidiseta (Steud.) Hitchc.				4	3	3	4	
Bromus catharticus Vahl							4	3
Cenchrus pauciflorus Benth.	3	3	3	3	4	4	4	4
Chloris cucullata Bisch	4	4		4	4	5		
Chloris latisquamea Nash				5				
Cynodon dactylon (L.) Pers.	4	3		4	4	3	3	3
Digitaria (aff. filiformis) (L.) Koel.	5							
Digitaria sanguinalis (L.) Scop.	5	5						
Digitaria (aff. villosa) (Walt.) Pers.					5			
Elymus canadensis L.							5	
Eragrostis sp.		4	3					
Eragrostis capillaris (L.) Nees	5	5						
Eragrostis frankii Steud.	4	4	4	4	4	4		
Eragrostis palmeri S. Wats.					5		4	
Eragrostis pectinacea (Michx.) Nees					5			
Eragrostis refracta (Muhl.) Scribn.					5	5		
Eragrostis secundiflora Persl	2	3	3	3	3	3	3	4
Eragrostis spectabilis (Pursh.) Steud.	5	5						
Eragrostis trichodes (Nutt.) Nash	5				5			
Eriochloa gracilis (Fourn.) Hitchc.				4	4			
Festuca octoflora Walt.				5				
Gymnopogon ambiguus (Michx.) B. S. P.					5			
Hordeum pusillum Nutt.	4	4		4	4			
Muhlenbergia capillaris (Lam.) Trin.	5							
Oplismenus setarius (Lam.) R. & Sch.	5	5			5			
Panicum anceps Michx.	4				5		4	
Panicum filipes Scribn.								5
Panicum helleri Nash	3	4	4	4	3	4	4	
Panicum hians Ell.				3	3			

Significance of numbers:
1=dominant; 2=subdominant; 3=frequent; 4=infrequent; 5=rare

GRASSES continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Panicum lindheimeri Nash	3	3	4	3	3	4		
Panicum rhizomatum Hitchc. & Chase	4	4			4			
Paspalum ciliatifolium Michx.	4	4			4			
Paspalum dilatatum Poir.					4	4		
Paspalum floridanum Michx.					4	4		
Paspalum Hartwegianum Fourn.	4	4			4	4		
Paspalum langei (Fourn.) Nash					4	4	4	
Paspalum plicatulum Michx.				4	4	4	5	
Phalaris caroliniana Walt.	3	3	4	3	3	4	3	4
Scleropogon rigida (L.) Griseh	5	5			4	5		
Setaria geniculata (Lam.) Beau.	4	3	3	4	3	4	3	
Setaria grisebachii Fourn.							4	4
Sorghastrum nutans (L.) Nash	4	4			4	4	4	4
Sorghum halpense (L.) Pers.	3	3		4	4	4		
Sphenopholis obtusata (Michx.) Scribn.	5							
Sporobolus asper (Michx.) Kunth						5	5	
Sporobolus clandestinus (Spr.) Hitchc.	4	4	3	4	3	4	4	
Sporobolus gracilis (Trin.) Merr.					5			
Sporobolus poiretii (R. & Sch.) Hitchc.	5	4	3	3	4	4		
Stipa leucotricha Trin. & Rupr.					3	3	2	2
Triodia drummondii Scribn. & Kearn	5	5						
Triodia flava (L.) Hitchc.	5	5	4					
Triodia stricta (Nutt.) Benth.	5			4				
Trisetum interruptum Buckl.							5	5
Uniola latifolia Michx.					5			
SEDGES								
Carex spp.	3	4	5	4	4	5		
Cyperus spp.	4	4	3	4	4	5	4	
Eleocharis sp.				5	5			
Fimbristylis castanea (Michx.) Vahl					5	5		
Rhynchospora sp.					5			
Scirpus nanus Spreng.					5			
Scleria oligantha Michx.						5		
FORBS								
Acalypha gracilens A. Gray	4	5						5

Significance of numbers:
1=dominant; 2=subdominant; 3=frequent; 4=infrequent; 5=rare

FORBS continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Adopogon occidentalis (Nutt.) Kuntze				5	5	5		
Allionia linearis Pursh.					5			
Allium arenicola Small				5	4	5	5	
Alsinopsis Nuttallii (T. & G.) Small				5		5		
Ambrosia aptera DC.								4
Ambrosia psilostachya DC.	3	3	3	4				
Amphiacyhris dracunculoides (DC.) Nutt.	3	3	3	3	3	3	3	4
Arabis virginica (L.) Trel.				5				
Artemisia ludoviciana Nutt.							4	4
Asclepiodora decumbens (Nutt.) A. Gray	5							5
Asclepiodora viridis (Walt.) A. Gray					5			
Ascyrum hypericoides L.	4	5			4			
Asper spp.	4	4	4	4	4	4	4	4
Aster Drummondii Lindl.	5	4			4			
Aster exilis Ell.	5	5	5		4	5		
Aster multiflorus Ait.					3	3	4	4
Baccharis neglecta Brit.	4	4		4	3	4		
Bacops procumbens var. peduncularis (Benth.) Fernald					5			
Baptisia leucophaea Nutt.				5	5			
Bellis integrifolia Michx.	5			5	5	5	5	
Berlandiera Texana DC.							5	4
Boltonia diffusa Ell.						5		
Callirrhoe involucrata (Nutt.) A. Gray				4	4	4	4	
Calyptrocarpus tampicana (DC.) Small					5			
Campsis radicans (L.) Seem.		5	5			5		
Carduus spinosissimus Walt.					5	5		
Castilleja indivisa Engelm.	4	4		4		4	4	
Cathartolinum Berlandieri (Hook.) Small							4	4
Cathartolinum multicaule (Hook.) Small	5	5		5	5	5	5	
Chaerophyllum Teinturieri Hook.							5	
Chamaecrista puberula Greene	4	4	3	3	3	3	3	4
Chamaecrista robusta Pollard	3	3	3	3	3	3	4	
Chamaesyce sp.	4	4						
Chamaesyce hyssopifolia (L.) Small	5	4			4	4	4	4
Chamaesyce serpens (H. B. K.) Small							4	
Chamaesyce stictospora (Engelm.) Small	4	4						
Chondrophora virgata (Nutt.) Greene					5			
Chrysopsis Nuttallii Brit.				5	3	4		
Chrysopsis pilosa (Walt.) Brit.				5	5	4		
Citrullus vulgaris Schrad.					4	4		

Significance of numbers:
1=dominant; 2=subdominant; 3=frequent; 4=infrequent; 5=rare

FORBS continued

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Cocculus carolinus (L.) DC.							5	
Commelina angustifolia Michx.				5	5	4	4	4
Commelina crispa Wooton				5	4	4		
Conoclinum coelestinum (L.) DC.	5							
Cooperia Drummondii Herb				5	5	5		
Cooperia pedunculata Herb					5			5
Croton capitatus Michx.	4	4						
Croton Engelmannii Ferguson	4	4	3	3	4	4	4	3
Croton Lindheimeriana Scheele	4	4						
Croton monanthogynus Michx.					4	4	4	
Croton texensis (Kl.) Muell. Arg.						5	4	
Cynosciadium pinnatum DC.				4				
Daubentonia longifolia (Cav.) DC.	4	4	5	4	4	4	5	
Delphinium vimineum C. Don	4	4		4	4	4	4	
Desmodium canescens (L.) DC.							5	
Dichondra caroliniana (Michx.) Choisy	5				5			
Diodia teres Walt.	5	4	4	4	5	4	4	
Dolicholus mininus (L.) Medic.							5	5
Dolicholus Texensis (T. & G.) Vail.	5					5		
Draba cuneifolia Nutt.							5	5
Elephantopus carolinianus Willd.	5							
Engelmannia pinnatifida T. & G.					4	4	3	4
Erigeron philadelphicus L.	4	4	5		4			
Erigeron quercifolius Lam.					5			
Eriogonum multiflorum Benth.	4							
Eupatorium compositifolium Walt.					5			
Eupatorium serotinum Michx.					5	4	5	
Eustoma Russellianum (Hook.) Griseb.						5		
Filago nivea Small							5	5
Froelichia gracilis (Hook.) Moq.				4	4	3	5	
Gaillardia sp.							5	
Gaillardia lanceolata Michx.	3	4	5	3	4	4	4	
Gaillardia suavis (A. Gray) B. & R.							5	
Gaura coccinea Pursh.								5
Gaura filiformis Small				4	4	4	4	
Gaura suffulta Engelm.					4	4	3	4
Geranium texanum (Trel.) Heller	5							
Gerardia Gattingeri Small				4	3	3	3	3
Gerardia heterophylla Nutt.				4	3	4	4	4
Gerardia homalantha Pennell	4	4	4	3	3	3	3	4

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FORBS continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Gerardia strictifolia (Benth.) Pennell				4	3	4		
Glottidium vesicarium (Jacq.) Desv.								
Gnaphalium falcatum Lam.				5				
Gnaphalium spathulatum Lam.	5				5			
Gratiola Virginiana L.				5				
Gutierrezia texana T. & G.	3	3	4	4	4	4	4	4
Hartmannia speciosa (Nutt.) Small	4	5			4	4	4	3
Helenium tenuifolium Nutt.	3	3	4	3	3	3	3	3
Helianthus Maximilianii Schrad.						4	3	4
Helianthus occidentalis Riddell	4	4	4	4	3	4		
Herbertia Drummondiana Herb.	5				5			
Heterotheca subaxillaris (Lam.) B. & R.	4	4	5	4	3	3	4	
Holcophacos distortus (T. & G.) Rydb.					5	5		
Holcophacos Engelmannii (Sheldon) Rydb.							5	
Houstonia angustifolia Michx.						4	4	
Hymenopappus carolinensis (Lam.) Porter		4	5	4	5			
Hymenopappus carymbosus T. & G.							4	
Indigofera leptosepala Nutt.							5	5
Ionoxalis Drummondii (A. Gray) Rose	4	4	5	4	4	4	4	4
Ipomoea trifida (H. B. K.) G. Don					5	5	4	4
Isopappus divaricatus (Nutt.) T. & G.	4	4	5	5	4	4	4	4
Isopappus Hookerianus T. & G.		4	4					
Iva angustifolia Nutt.	4	3		3	3	4		
Iva ciliata Willd.						4	4	
Juncus sp.				4			5	
Juncus bufonius L.				4				
Juncus effusus L.	5	5			5			
Lathyrus pusillus Ell.							5	
Lechea tenuifolia Michx.	3	4			4			
Lechea villosa Ell.							5	
Lepadenia bicolor (E. & G.) Nieuw.	4	3			4	4	3	3
Lepidium austrinum Small							5	
Lepidium medium Greene				4	4	4	4	
Leptilon canadensis (L.) Brit.	4	3	4	4	4	4		
Lespedeza sp.				4				
Lespedeza hirta (L.) Ell.	5							
Lespedeza intermedia (S. Wats.) Brit.	5							
Lespedeza procumbens Michx.					4	5		
Lespedeza Stuvei Nutt.	5							
Lespedeza Texana Brit.			4					
Lespedeza virginica (L.) Brit.		4	3		4			

Significance of numbers:
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FORBS continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Liatris angustifolia (Bush) Gaiser.							5	
Liatris Earlei (Greene) K. Sch.					4	4	5	
Liatris pycnostachya Michx.					4	4	3	4
Liatris squarrosa Willd.						5		
Linaria texana Scheele				5	5			
Lindheimera texana Engelm. & Gray						4	4	
Lithospermum linearifolium Goldie						5	5	5
Ludwigia glandulosa Walt.						5		
Lupinus subcarnosus Hook.	4	5	5	4	5			
Lupinus texensis Hook.								4
Lygodesmia texana (T. & G.) Greene							4	4
Malvaviscus Drummondii T. & G.							5	
Margaranthus solanaceus Schlecht.								5
Marilaunidium Jamaicense (L.) Kuntze					5			
Marshallia caespitosa Nutt.					5			
Mauchia hirtella (T. & G.) Kuntze			4	4	4	5	5	
Mecardonia procumbens (Mill.) Small					5			
Medicago arabica (L.) Huds.					5			
Medicago denticulata Willd.						5		
Meibomia Lindheimeri Vail	4	4	4	4	5			
Melilotus alba Desv.				4	3	4	3	4
Melilotus indica (L.) All.						4	4	
Meriolix spinulosa (T. & G.) Heller					4	4		
Mesadenia tuberosa (Nutt.) Brit.	5							
Modiola caroliniana (L.) A. Gray	5	5			5			
Monarda teniuaristata (A. Gray) Small						5		
Morongia uncinata (Willd.) Brit.					5			
Myosotis virginica (L.) B. S. P.	5				5			
Nothoscordium bivalve (L.) Brit.				4	4	4	4	
Oenothera laciniata Hill	5						5	
Paronychia chorizanthoides Small				3	4			
Paronychia Lindheimeri Engelm.	5	5						
Parthenium Hysterophorus L.						5	4	4
Pentsemon cobaea Nutt.							5	
Pentsemon laxiflorus Pennell					5			
Persicaria Opelousana (Ridd.) Small						5		
Persicaria Pennsylvanica (L.) Small	5							
Persicaria Persicaria (L.) Small							5	
Persicaria persicarioides (HBK) Small					5			
Persicaria punctata (Ell.) Small	4				5			
Petalostemon multiflorus Nutt					5			

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FORBS continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Petalostemon Stanfieldii Small						4		
Phaca sp.							4	
Phacelia patuliflora A. Gray							5	5
Phlox cuspidata Scheele				4		5	5	
Phlox cuspidata var. grandiflora Whitehouse				5				
Phlox Drummondii Hook.	5				5			
Phyla nodiflora (L.) Greene						5		
Phyllanthus polygonoides Nutt.								5
Physalis angulata L.	5							
Physalis mollis Nutt.							5	
Phytolacca americana L.				5	5			
Plantago aristata Michx.					5			
Plantago rhodosperma Decne.					4	5	4	
Plantago Virginica L.	4	5		4	5	4	4	
Pluchea camphorata (L.) DC.						5	4	
Pluchea petiolata Cass.					4	4		
Poinsettia dentata (Michx.) Small					5	5	5	5
Polygala alba Nutt.							4	
Polygala incarnata L.							5	
Polypremum procumbens L.	4	5		5				
Polypteris callosa (Nutt.) A. Gray	3	4	4	4	3	4	4	5
Ptilimnium capillaceum (Michx.) Hollick				4			5	
Ranunculus sceleratus L.					5			
Rubus trivialis Michx.	4	4	5	4	4	5	5	4
Rudbeckia bicolor Nutt.					5	4	4	4
Ruellia spp. L.					4	5		
Ruellia humilis Nutt.	4	4	5		4	5	4	4
Ruellia nudiflora (E. & G.) Urban	5	5	5		4	5	4	4
Ruellia Runyovi Tharp & Barkley				5				
Rumex hastatulus Baldw.	5	5	5	4	5	4		
Sagittaria graminea Michx.				5			4	
Salvia lyrata L.						5		
Salvia Pitcheri Torr.	4	4		4	5			5
Sanicula canadensis L.						5		
Sarothra Drummondii Grev. & Hook.	3	4	4	4	4	4	3	
Scutellaria Drummondii Benth.	5	5	4	4	5	5	5	5
Senecio ampullaceus Hook.				5	5			
Sida angustifolia Lam.			5		5			5
Sida ciliaris L.	5						5	
Sida longipes A. Gray					5			

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FORBS continued:

Name of Plant	Geologic Formational Units							
	Yegua	Caddell	Middle member of Wellborn	Carlos member of Wellborn	Manning	Whitsett	Catahoula	Oakville
Sisyrinchium pruinosum Bicknell				4	5	4		
Sitilias multicaulis (DC.) Greene				5				
Smilax bona-nox L.				4	4	4	4	4
Solanum elaeagnifolium Cav.							4	4
Solanum nigrum L.					5			
Solanum rostratum Dunal							5	5
Solanum Torreyi A. Gray						5		
Solidago sp.			4	5	4	4	4	5
Solidago Canadensis L.	5							5
Solidago radula Nutt.	4	5			4			
Sonchus asper (L.) Hill								5
Specularia biflora (R. & P.) F. & M.	5			5				
Specularia perfoliata (L.) A. DC.							5	
Spermolepsis inermis (Nutt.) M. & C.	5					5	4	
Spiranthes vernalis E. & G.					5			
Stachys agraria Cham. & Schlecht.					5	5		
Strophostylis helvola (L.) Ell.						5		
Taraxacum Taraxacum (L.) Karst.								5
Teucrium canadense L.						5		
Tithymalus Arkansanus (E. & G.) K. & G.							5	
Tithymalus leiococcus (Engelm.) Small				5				
Tithymalus tetraporus (Engelm.) Small					5	5		
Torilis nodosa L.								5
Toxicodendron Toxicodendron (L.) Brit.	4	4			4	5	5	4
Tradescantia subacaulis Bush				5				
Tragia ramosa Torr.					5			
Trichostema dichotomum L.	5	5	4					
Trifolium bejariense Moric				5	5	5		
Trifolium carolinianum Michx.	5			5				
Triodia drummondii Scribn. & Kearn.	5							
Verbena Halei Small	4	4	4	4	4	4	3	4
Verbena pinnatifida Nutt.						4	3	4
Verbesina virginica L.	4	4			5	4	3	4
Veronica perigrina L.				5				
Vernonia texana (A. Gray) Small	4	5			4	5		
Vicia Leavenworthii T. & G.	3	3	4	3	3	3	3	4
Vigna sinensis (L.) Endl.					4		4	4
Viguiera helianthoides H. B. K.								4
Xanthium speciosum Kearney	4	4			4			
Xanthoxalis corniculata (L.) Small	4	4	5	5	5	5	4	
Xanthoxalis stricta (L.) Small	4	4	5	5	4	5		

Significance of numbers:
1=dominant; 2=subdominant; 3=frequent; 4=infrequent; 5=rare

SELECTED REFERENCES

Bailey, T. L. (1927) The Gueydan, a new Middle Tertiary formation from the southwestern Coastal Plain of Texas: Univ. Texas Bull. 2645, 179 pp., 3 figs., 12 pls.

Berry, E. W. (1916) The flora of the Catahoula sandstone: U. S. Geol. Survey, Prof. Paper 98, pp. 227-251, 6 pls.

Blanpied, B. W., and Hazzard, R. T. (1935) Stratigraphy and paleontological notes on the Eocene (Jackson group), Oligocene, and lower Miocene of Clarke and Wayne counties, Mississippi (abst.): Am. Assoc. Petroleum Geologists Bull., vol. 19, no. 4, pp. 571-575.

Bowling, Leslie, and Wendler, A. P. (1933) Detailed study of some beds, commonly known as Catahoula formation, in Fayette County, Texas, with particular reference to their age: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 5, pp. 526-547, 4 figs.

Cooke, C. W., Gardner, Julia, and Woodring, W. P. (1943) Correlation of the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean region: Geol. Soc. America Bull., vol. 54, no. 11, pp. 1713-1722, 1 pl.

Deussen, Alexander (1924) Geology of the Coastal Plain of Texas west of Brazos River: U. S. Geol. Survey, Prof. Paper 126, 145 pp., 38 figs., 36 pls.

Dumble, E. T. (1892) Report of the brown coal and lignite of Texas; character, formation, occurrence, and fuel uses: Texas Geol. Survey, 243 pp., 1 pl.

_____ (1894) The Cenozoic deposits of Texas: Jour. Geology, vol. 2, pp. 549-567.

_____ (1903) Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, pp. 913-987, 1 pl.

_____ (1918) The geology of east Texas: Univ. Texas Bull. 1869, 388 pp., 12 pls.

_____ (1924) A revision of the Texas Tertiary section with special reference to the oil-well geology of the coast region: Am. Assoc. Petroleum Geologists Bull., vol. 8, no. 4, pp. 424-444.

Ellisor, A. C. (1933) Jackson group of formations in Texas with

notes on Frio and Vicksburg: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, pp. 1293-1350, 8 figs., 7 pls.

Galliher, E. W. (1935) Geology of Glauconite: Am. Assoc. Petroleum Geologists Bull., vol. 19, no. 11, pp. 1569-1601, 16 figs.

Gruner, J. W. (1935) The Structural Relationship of Glauconite and Mica: Am. Mineralogist, vol. 20, no. 10, pp. 699-714.

Hay, O. P. (1924) Description of some fossil vertebrates from the Upper Miocene of Texas: Biol. Soc. Washington Proc., vol. 37, pp. 1-19, 2 figs., 6 pls.

Hilgard, E. W. (1860) Report on the geology and agriculture of the state of Mississippi, 391 pp., 3 pls., Jackson, Mississippi.

Hill, R. T. (1901) Geography and geology of the Black and Grand prairies, Texas: U. S. Geol. Survey, 21st Ann. Rept., pt. 7, 666 pp., 80 figs., 71 pls.

Kennedy, William (1993) Report on Grimes, Brazos, and Robertson counties: Texas Geol. Survey, 4th Ann. Rept., pt. 1, pp. 1-84, 2 figs., 3 pls.

Krumbein, W. C. (1936) Application of logarithmic moments to size frequency distribution of sediments: Jour. Sedimentary Petrology, vol. 6, no. 1, pp. 35-47, 5 figs., 2 tables.

_____ (1936) The use of quartile measures in describing and comparing sediments: Am. Jour. Sci., 5th ser., vol. 37, no. 188, pp. 98-111, 5 figs.

_____, and Pettijohn, F. J. (1938) Manual of Sedimentary Petrography, D. Appleton-Century Co., New York, N.Y., 549 pp.

Leidy, Joseph (1861) On fossil teeth from Washington County, Texas: Acad. Nat. Sci. Philadelphia, Proc. 1860, p. 416.

Moody, C. L. (1931) Tertiary history of region of Sabine uplift, Louisiana: Am. Assoc. Petroleum Geologists Bull., vol. 15, no. 5, pp. 531-551, 5 figs., 1 pl.

Penrose, R. A. F. (1890) A preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande: Texas Geol. Survey, 1st Ann. Rept., pp. 3-101.

Plummer, F. B. (1932) The geology of Texas, part 3, Cenozoic systems in Texas: Texas Univ. Bull. 3232, pp. 519-818, 27 figs., 4 pls.

Renick, B. C. (1936) The Jackson Group and the Catahoula and Oakville Formations in a part of the Texas Gulf Coastal Plain: Univ. Texas Bull. 3619, 104 pp., 10 pls.

Schneider, Hyrum (1927) A study of glauconite: Jour. Geology, vol. 35, no. 4, pp. 289-310, 2 figs.

Shumard, B. F. (1863) On the discovery of dicotyledonous leaves in the Cretaceous of Texas: Acad. Sci. St. Louis Trans., vol. 2, pp. 140-141.

Simpson, G. G (1933) Glossary and correlation charts of North American Tertiary mammal-bearing formations: Am. Mus. Nat. Hist. Bull., vol. 67, art. 3, pp. 79-121, 8 figs.

Trask, P. D. (1932) Origin and environment of source sediments of petroleum, 323 pp., 38 figs., 1 pl., Houston, Texas, Gulf Publishing Co.

Veatch, A. C. (1906) Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey, Prof. Paper 46, 422 pp., 33 figs., 49 pls.

Weeks, A. W. (1933) Lissie, Reynosa, and upland terrace deposits of Coastal Plain of Texas between Brazos River and Rio Grande: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 5, pp. 453-487, 4 figs.

Wentworth, C. K. (1922) A scale of grade and class terms for clastic sediments: Jour. Geology, vol. 30, no. 5, pp. 377-392, 3 figs.

_____ (1926) Methods of mechanical analysis of sediments: Univ. Iowa Studies in Nat. Hist., vol. 11, no. 11, 52 pp., 9 figs.

Wood, H. E. (1941) Nomenclature and Correlation of the North American Continental Tertiary: Geol. Soc. America Bull., vol. 52, no. 1, pp. 1-48, 1 pl.

_____, and Wood, A. E. (1937) Mid-Tertiary vertebrates from the Texas Coastal Plain; fact and fable: Am. Midland Naturalist, vol. 18, no. 1, pp. 129-146, 5 figs.

Woodring, W. P. (1928) Miocene Mollusks from Bowden, Jamica; Part II. Gastropods and discussion of results: Carnegie Inst. Washington Pub. 385, 564 pp., 3 figs., 40 pls.

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Plate I

GEOLOGY OF MULDOON AREA

SOUTHWESTERN FAYETTE COUNTY, TEXAS

ALFRED L. RIPPLE JUNE, 1951

TRUE NORTH
MAGNETIC NORTH
9°

EXPLANATION

	Qal	Alluvium — Flood plain deposit of present streams	QUATERNARY
Holocene	Mo	Oakville — Gray clay with calcareous sand lenses	TERTIARY
		DISCONFORMITY	
Miocene	Mc	Catahoula — Greenish-gray tuffaceous, bentonitic shale, clay, and gray tuffaceous sand, containing some calcareous sandstone and silicified wood	
		DISCONFORMITY	
Oligocene	Ewh	Whitsett — Tuffaceous sand and sandstone, bentonitic clay and silicified wood	
Eocene	Em	Manning — Chocolate-colored lignitic clay, tan tuffaceous sand and sandstone	
Jackson group	Ewlc	Carlos member of Wellborn formation — Whitish-gray sandstone	
	Ewl	Middle equivalent of Wellborn formation — Argillaceous fine sand	
	Ec	Caddell — Clay, shale, and tan sand with glauconitic sand and calcareous sandstone	
		DISCONFORMITY	
Claiborne group	Eye	Yegua — Lignitic clay and gray sand	

Scale 1/24000

0 .1 .2 .3 .4 .5 .6 .7 .8 .9 Mile
0 1000 2000 3000 4000 5000 Feet

EXPLANATION

- Geologic formation boundaries (observed, inferred, and covered by younger deposits)
- Faults (observed and inferred)
- Normal fault (U, upthrown side; D, downthrown side)
- Measured geologic section and number
- Permanent benchmark and elevation
- Supplementary benchmark and elevation
- Water tank = ▫ Building and ruin
- Electric transmission line
- Gas well ⛭ Stone quarry, inactive

Muldoon
Rocky Crossing Lake
Wrightman Crossing
Henson Cem
Pitman Cem
Ruth Cem
Abandoned clay pit
Sylar and Wrightman clay pit
Murdoon Oil & Gas Co O B Robinson No 1
Ivey clay pit
Parker clay pit
Cherry clay pit
Lake
Chandler Creek
Buckners Creek
Beaty Branch
Pin Oak Creek
Live Oak Creek
Dogwood Creek
Salt Branch
Alligator Creek
Tuttle Creek
Emerson Creek
Blackjack Creek
Gregor Branch
Black Creek
Salinas Creek
Cochran Branch
Navidad River
North Fork of the Navidad River
Old La Grange Road
Farm Road No 154
New Orleans and Texas R R
Texas and New Orleans R R
J DALRYMPLE
M MULDOON
J BARTLETT
J HARPER
M SMITH
THOS O BERRY
G W KEAN
E Y KEAN
DAVID BERRY
WM HIGGINS
J M FERRILL
L W T PEEBLES
NORA CARNES
S F KNIGHT
B GREEN
J B TATOM
JOS D ELLIOT
J MAMOLINA
J SCHRADER
WM H WALTON
F A BETTINGER
S COTTLE
E DEVER
VIVEN
EVANS
29°50'
29°45'
97°05'

COMPOSITE SECTION
MULDOON AREA
FAYETTE COUNTY, TEXAS

ALFRED L. RIPPLE JUNE. 1951

Feet

900 — Oakville Formation / Catahoula Formation

850

800

750

Catahoula Formation / Whitsett Formation

700

650

Whitsett Formation / Manning Formation

600

550

500

450

400

350

300

250

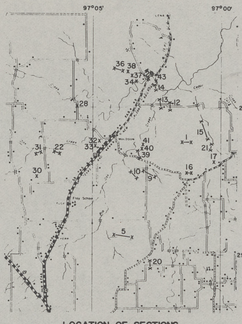
200 — Manning Formation / Wellborn Formation / Carlos sandstone Member Wellborn / Wellborn Formation / Caddell Formation

150

100

50

0 — Caddell Formation / Yegua Formation



LOCATION OF SECTIONS

Scale 0 1 2 3 4 MILES

EXPLANATION OF SYMBOLS

- Thin bedded sand and silt
- Bentonitic clay
- Cross bedded glauconitic sand
- Carbonaceous, lignitic shale
- Massive tuffaceous sand
- Lignite
- Calcareous sand
- Clay pebbles, nodules, boulders
- Sandy clay
- Calcareous concretions
- Clay
- Fossil worm boreholes
- Shale
- Silicified wood
- Calcareous clay
- Fossils